

1485. p. 22.



The MODERN

Navigator's Compleat Tutor ;

OR, A

TREATISE

Of the Whole ART of

NAVIGATION

In its THEORY and PRACTICE, &c.



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IN BROAD-STREET, WAPPING, near
Wapping New-Stairs, are Taught these fol-
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The MODERN
Navigator's Compleat Tutor:

OR, A
T R E A T I S E

Of the Whole ART of
Navigation in its Theory and Practice.

CONTAINING

I. *Domestick or Coasting Navigation*, Sundry Notes
of the Moon's Motions, Calender, Tides, &c.

II. *Theoretical Navigation*, by various Methods, viz.
Geometrical, Logarithmetical, Tabular, and by the Pen
only (without Tables or Instruments.) Together with
Practical Astronomy, the Description, Construction, and
Use of the Plain and Mercator's Charts, and other
Nautical Instruments, &c.

III. *Practical Navigation*; the Application of the
Theory to Practice, in keeping a Sea-Journal, the work-
ing a Day's Log at Sea, in all Cases whatever (with Ra-
tional Corrections :) Illustrated with full, proper, and
practical Examples of the same. The whole more, *amply*
and *plainly* demonstrated, than in any Treatise of this
kind extant. To which are added,

All Necessary Tables *Nautical and Astronomical*, for the
Mariner's Practice by Inspection.

Also an APPENDIX,

Touching pleasant and critical Questions in *Navigation*; with
divers other things both *Curious and Useful* in this Art.

PART I. The Second Edition, Enlarged.

By JOSHUA KELLY, Mariner, and Teacher of
the *Mathematicks*.

L O N D O N,

Printed for W. Mount and T. Page on Tower-Hill; J. Wilcox
against the New Church in the Strand; J. Clarke in Duck-
Lane; J. Eade near King Edward's Stairs, and B. Macey on
Hermitage-Bridge in Wapping. MDCCLXXXIII.



TO THE
 Rt. Honourable and Rt. Worshipful the
M A S T E R,
 THE
 Wardens, Assistants, and Elder Brethren
 OF THE
TRINITY-HOUSE
 OF
Deptford - Strond, &c.

GENTLEMEN,



THE Oblig'd Author, with all Submission, devotes the ensuing Treatise to you (as your just Right,) not doubting but by your great Sagacity, and penetrating Judgment in this kind of Learning, you will readily perceive, that my sincere Intention of doing service to the World, hath animated me to publish this Epitome of the *Mariners*

ner's Art, for which, and the Publick Good, you have always been so conspicuously zealous; particularly by your encouraging this Noble and Useful Science, wherein the Safety, Wealth and Glory of the *British* Nation are so much concern'd. I am well assur'd, that no Person without your Examination and Approbation, can be admitted to Publick Mathematical Services in the Royal Navy, &c. and that, bringing all such Persons to the Scrutiny, as their Merit; so your Countenance appears.

THIS Art, Gentlemen, I undertake to Teach, and offer to the World, having grown up with me from my Minority, being the result of a long Theory, and many Years Experience at Sea, in quality of *Mate, Master* and *Instructor* to the Gentlemen-Volunteers in his Majesty's Royal Navy, appointed (after a strict Examination) by Your Board. I'm not without hopes of being accepted in this my Address, and presume therefore to make choice of so Honourable a FRATERNITY for my PATRONS; who are deservedly Famous for your superlative Knowledge in *Maritime Affairs*, and by all justly esteemed the Ablest Masters in this Art, as well as the most proper Judges of Works of this nature: Your very Names will excite the Young Student in *Navigation* to a diligent Application, when he considers your Candor, Generosity, and propitious Inclination towards all who endeavour

Epistle Dedicatory. iii

deavour any way to promote or improve by it the true *English* Interest.

THEREFORE, if my Performance herein may but obtain your Approbation, and your Acceptance give it an *Imprimatur*, I shall be the less concern'd at the carping Censures of *Zoilus* and *Momus*, (or any such, who prefer their own private Interest to the Publick Good;) and be the more encourag'd to spend the residue of my Days in promoting this Famous ART, in which I have already spent a great part of the Studies of my past Life: And, among the Numbers I have Taught, have not long since, had the Honour of instructing some of your Sons, Relations, &c.

THIS, *Gentlemen*, further emboldens me to cast my Mite into your Treasury; which, as a small Pledge of my Esteem for your Favours, I beg you will be pleased to accept.

I shall conclude this *Dedication*, with the grateful and pleasant Reflection all must have of the great Honour and Benefits which accrue to the *British* Dominions by your Wise Conduct and Indefatigable Applications, and by your publick Zeal for the Common-Weal. 'Tis the Courage of some of your Honourable Brethren, that has quell'd the Pride of MONSIEUR, removed War from our Doors, and planted the O-

live-Branch in the midst of *Great-Britain*: 'Tis the Conduct of others, that has transported into our Island the Wealth of both *Indies*, carry'd away our Superfluities, and brought us home our Conveniencies; making the Pleasures, Riches and good Things of the whole World common to all Mankind: 'Tis the Vigilance of others, that renders our Sands and Shoals navigable, procuring Sea-Marks, Light-Houses, &c. for the safety of Shipping: And 'tis Your Sagacity also that procures Able Masters and Pilots for our Ships of War, and of Merchants, &c. And, to name no more, ne'er a Society in *Europe*, Ecclesiastical or Civil, can equal your extensive Charity, in maintaining decently such a Number of poor Seamens Widows, &c. These not only raise Admiration in all Men, but excite the best to pray for you, and the Prosperity of your *Worthy Fraternity*: With whom sincerely joins,

GENTLEMEN,

Your most Obliged, and

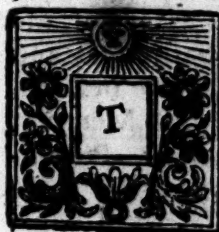
Most Obedient Humble Servant,

Joshua Kelly.

THE
P R E F A C E

To all Lovers and Learners of

N A V I G A T I O N.



IS an uncontroverted Maxim, allow'd by all, and best known by those of the Noble Tribe of *Zabulon*, That the Art of Navigation, by which Islands are enrich'd and preserv'd in Safety from Foreign Invasions; the wonderful Works of an Omniscent Creator, in the wide extended Ocean and remote Nations, are delightfully beheld, &c. is a very excellent and necessary Art; and that 'tis no mean Accomplishment, to be capable of conducting a Ship richly laden, round the World. Neither can it be deny'd, that the Riches, Safety, and Glory of *Great Britain*, consist in its Naval Power: (For the more it is improv'd, the more Great, the more Safe and Rich, will these Kingdoms be; and on the contrary, the more the Navigation and Naval Power is diminish'd or discourag'd, these Nations will be the more Mean, the more Poor and Insecure.) This Art not being as yet arriv'd to its *Ne plus ultra*, will admit of further Improvements, till God shall permit us to discover a certain Method, for finding the Longitude at Sea. I shall therefore, in Compliance to Custom, say something as Prefatory to the ensuing Treatise; and why I undertook the Publication thereof, in an Age that so abounds with Books of this nature: But the Difference

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Difference between them and this will appear obvious (to the Knowing and Impartial Reader,) by comparing 'em together. For besides that want of a plain and regular Method in *THEORY*, and the Defect of sufficient Tables and demonstrative Examples in the *PRACTICE* of this Art, in the several Books of this kind extant; most of these are either too Voluminous, and tend rather to Distract than Instruct; and so the Learner is deterr'd or discourag'd from the Study: Or else too abstruse and perplex'd, being promiscuously fill'd with unnecessary Problems, and intermix'd with Things foreign to the Art of Sailing. I have therefore, (for the sake of those who value the solid and substantial Part of this Science, rather than useless Speculations,) here omitted nothing that may be of use to the Mariner; but made it a general Treatise of Navigation, (both for *Curiosity* and *Usefulness*.) to supply the Defect of all other Books of this kind: And in endeavouring to make the Method throughout the whole, uniform, plain, and perspicuous as possible, I have given such Cases only, as are of use to the Mariner in the several kinds of Sailing; and have applied such Examples to each, as may best demonstrate their Operation, be most easie for Memory, and applicable to Practice. And all the *Rules*, *Projections*, *Analogies*, manner of working and resolving those Cases, according to the various Methods inserted, I hope, are explain'd in a natural Order, in short and clear Terms, to render them easie to the understanding of the most indifferent Capacity. Nor can I conceive there is any thing material omitted, or any thing inserted superfluous, or which was not necessary to make the Body of the Book correspondent to the Title-Page: Besides, there are some Improvements in the *Theory*, and such full and demonstrative Examples in the *Practice* or Journal-part, that I think I may affirm, have not hitherto been treated of by any; and in such an Experimental Method, as I have taught and practis'd with Success, both at Home, and in Foreign Voyages, for near Thirty Years, (in the various Stations of *Mate.* *Master.* *Regular.* *Sworn* and *Warranted Teacher of the Mathematicks*, to the *Gentlemen Volunteers* in his Majesty's Royal Navy.)

As

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As for the Style, 'tis plain, and suited to the Meridian of Seamen; who undoubtedly will search here for Truth and Usefulness, and not for Rhetorical Eloquence; (Accomplishments seldom courted by the Honest Sailor, for they will never help him to a good Land-fall, nor keep his Ship from a Lee-shoar.)

Thus having laid my Labours before the Courteous Readers, who are most likely to receive Profit thereby, at a small Charge; I must entreat others to use me as they would themselves be us'd, which is the spontaneous Act of every Good Man; and desire that what *Errata* have crept in, thro' the Printer's means, or my own Oversight, the Reader would pass over: For neither He, nor I nor any of the Sons of *Adam*, (nor their Writings,) are infallible, since according to the Proverb,

Nemo sine crimine vivit.

No Man e'er liv'd (on Earth) nor ever shall,
That did all well, and had no Fault at all.

And as Mr. *Pope* says,

Whoever thinks a Faultless Piece to see,
Thinks what ne'er was, nor is, nor e'er shall be.

Altho' my Design here is more intended for Publick Good, than my own Private Interest; (for this Age seldom attempts the writing in a Mathematical way for Profit;) yet, no doubt, the carping *Mom*i may pick some Criticisms out of the Book. To such I shall only in Modesty say, 'Tis much easier for those captious Readers to carp than amend. This is indeed, a scribbling Age, that pesters us with many useless Pieces, where the Authors write out of Spleen, Pride, or for the getting of Money. But such a Subject as this needs no Recommendation, one would think, in such a Nation as this, so flourishing in Trade and Shipping; yet, no doubt, this Piece will not be equally esteem'd by all: Thro' Partiality and Self-Interest some, perhaps, may condemn such Performances: For indeed this Age produces little else but Drollery and Ridicule by bawling Wits, who can only canvass at a Word, or clamour

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at a Phrase in an Author. And such *Herostratus's*, *Nugator's*, and *Ardelio's*, that would fain almeccanthesize themselves from the Nadir of *Ignoramus*, to the Zenith of *Non Parallels*, because they cannot get a Name by any eminent Work of their own, seek it in the destroying that of others: But we must let 'em know, it is easier to be a Critick than an Author. And if he who would judge impartially of an Undertaking of this nature, would but take the Pains to make himself Master both of the Theory and Practice of this Art, and then essay something of the like Kind, (for Authors should be try'd by their Peers,) we should be rid of those detracting Enemies. I wish it were not to be said, that this Noble and Useful Art hath of late Days been made Contemprible; by the Number pretending to teach it, that want the necessary Qualifications, and have never been in the Practice thereof at Sea; and consequently the Learner with such, spends his Money and Time to very little real Advantage: I shall therefore, with Submission to better Judgments, presume to offer the following Truths, which I've asserted long since to the Publick on the *Royal Exchange*, viz.

I. That the generality of the Teachers of Navigation, are very much to seek in the Practical and most necessary Parts of this Art.

II. That several are also very imperfect in the *Theory*, and altogether Strangers in the *Practice* of keeping a Sea-Journal; or the working a Day's Log, in all the various Cases of Winds, Weather, making and short'ning Sail, Tying, Hulling, &c.

III. That many of these do not make Teaching their only Business; but are too frequently employ'd in their proper Callings, Trades, Shop-keeping, &c. to the great Hindrance, expence of Money and Time of the Learner; (who generally is under a Necessity of making a speedy Application.)

IV. That

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IV. That it is not the Learning a few *Problems* from such kind of (negligent) Half-Teachers ; but a thorough Knowledge of both the *Theory* and *Practice*, that will make a Man a compleat Artist. And all know, that this Art is not a Matter of so trifling Knowledge, and so indifferent whether it thoroughly understood or not ; but 'tis a Science of the utmost Importance, wherein the Lives and Estates, the Good of both the Publick and Private are in danger from a small Mistake committed therein ; and therefore, should be taught or learn'd to the utmost Perfection : And by Consequence, Honesty, Fidelity, due and constant Care and Attendance, with a sufficient Skill in both the *Theory* and *Practice*, are, or ought to be, inseparable Qualifications in an Able Teacher.

Si reprehendi fers agere, reprehendenda ne feceris.

It would be well that these things were inspected by Learned Judges of this kind of Learning ; and that such Persons would observe, what was inculcated by the Poets, when they feign, that their Gods do content themselves within the Compass each of his own Sphere ; *Mars* medleth with *War*, *Minerva* with *Arts*, *Mercury* with *Eloquence*, *Jupiter* with *Heaven*, *Pluto* with *Hell*, *Cupid* with *Love*, *Neptune* with the *Sea* : And consequently, this Science more immediately pertains to the *Mariner* to be Master of ; and not to such Land-Navigators, who have learn'd to swim without going into the Water ; and to sail on a Slate and Paper only. I'm apt to believe, these Persons would have but few Pupils, were they not daily to frequent Publick-Houses, and by Ostentation, insinuate and boast of their great Ability this way among *Ignoramus's* : And, as a late Author observes, many that are about to learn, apply to any one that will teach cheapest ; not considering, that the very Reason why they do so, is commonly the want of sufficient Ability to recommend themselves any other way : And then it is too common, as soon as One has been taught, (and perhaps but a Green-Head, before his Understanding be well ripe, he shall underrake to teach another ; and that other a Third, and so on. Now if we suppose the Best, *viz.* That the first Person was well Taught ;

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Taught; yet it must be consider'd, that tho' he that undertakes to teach an Art, must be Master of it; (or according to the Poet,

He that hath Art, and can impart
That Art, with Art, is Master of his Art:

Yet it must be own'd, 'tis not every one that is Master of an Art, that is equally qualify'd to teach it; since many times, it is much more difficult to communicate an Art to another, than it is to attain it our selves; and the Reason is obvious, because first, this must be gain'd by much Practice in Teaching, and having a thorough Knowledge of the Theory: That the Tutor may be able to give different Explanations of a *Proposition*; that if one does not suit with his Pupil's Understanding, another may. Secondly, the Capacities and Tempers he has to do with, may be as various as the Number of his Scholars: (These, and many things more might be nam'd.) So that his first Care must be a suitable and plain Method; and prudently to make a right Judgment of their several Capacities and Tempers, when he deals out Instructions to them: For 'tis a known Maxim, that even every good Scholar is not equally qualify'd for Teaching. I would not be thought Magisterial or Satyrical in these Cases, in detecting some Mens Practices: I'm perswaded the qualify'd Teachers of this Art, (whose Number is but small in this great Metropolis,) will acquiesce with me; and shall only say, if the World is resolv'd to favour such Impositions, in Matter of this Consequence, 'tis their own Choice, nor want of Discovery in me: I shall here therefore beg leave to add the Words of the Great *Cicero*, viz. "Every Thought and Motion of the Mind, ought to be employ'd either in consulting of honest Things, and such as may lead to a good and happy Life; or in the Study of Arts and Sciences, and the way to gain Knowledge: For we are all drawn, or as it were, led by the Hand to a Desire of getting Knowledge, and bettering our Understanding; wherein to excel is accounted an excellent thing; but to stray from, be ignorant of, or easily deceiv'd, not only by others, but also by our selves, is a great stain to Reputation.

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The general Approbation and Encouragement the First Edition hath met with, both in the Royal Navy, and in Merchant-Ships, hath induc'd the Proprietors not only to Print a larger Number, with Additions, and Corrections; but also to be at the Charge of a Second Part, or Volume, being a Compleat and Methodical Treatise of Practical Astronomy, Plain and Spherical Trigonometry, and the Doctrine and Projection of the Sphere, the various Questions of the Sun and Fixed Stars exhibired and demonstrated Geometrically, Logarithmically and Instrumentally; with Great Circle (Spherical, or Globular) Sailing, the Use of the Celestial and Terrestrial Globes, &c.

To conclude therefore: If this Fruit of my Labour find good Acceptance in the World, I shall think my Pains well bestow'd.

And that my Learner may reap the Benefit hereby intended him; and that Success and Prosperity may attend his Lawful Study and Undertakings, is the Desire of him that wisheth the young Student's Proficiency, and the Progress of all useful Arts.

From my School in
Broad-street, Wapping,
May 1. 1733.

J. Kelly.

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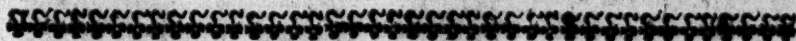
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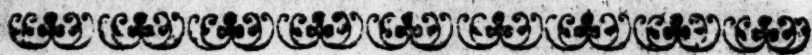
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*An Explanation of the Symbols or Characters us'd
in this Treatise (for brevity sake.)*

$+$	More, or add; as, $A + B$, is A more B.
$-$	Less, as subtract; as, $A - B$, is A less B.
$\times$	In, or multiply; as $A \times B$, is A multiply'd by B.
$\div$	By, or divide; as $A \div B$, is A divided by B.
$∴$	Rule of Three; $A ∴ B ∴ C ∴ D$, i.e. or Di- rect Proportion; as A is to B, so is C to D.
S.	Sine.
S.C.	Sine Complement.
T.	Tangent.
T.C.	Tangent Complement.
Sec.	Secant.
Sec.C.	Secant Complement.
R.	Radius or Sine of 90 Degrees.
Σ.	Sum.
Δ.	Difference.
$=$	Equality; as $A = B$, is equal to B.
$\sqrt{\quad}$	Radicality, or Square Root; as, $\sqrt{144}$ 12 i.e. the Square Root of 144 is 12.
∠	Angle.





The Compleat
Modern Navigator's TUTOR:
 OR,
NAVIGATION
 IN ITS
Theory and Practice, Curiosity and Utility.

P A R T I.

C H A P. I.

Domestick or Coasting NAVIGATION.



OF the common Notes of
 the *Julian Kalendar*, and
 such other NOTES of
 the Moon's Motion, as
 are necessary to be
 known by the Young
 Navigator.

LUNA, the Goddess of the
 silent Night,
Phæbe, Diana, various Flux
 of Light,

Prime Ruler of moist Bodies, and of what's contain'd
 In Water-works, whether by Sea or Land.

B

She's

She's the lowest Planet, who in seven
 And twenty Days goes round the Heaven :
 And about two Days more that she must run,
 Before that she doth overtake the Sun :
 So twenty nine and half she rounds her silver Ball,
 To make one Month we call *Synodical*.
Cynthia, thou second Honour of the Lamps supernal,
 And sure Calendar of Festivals eternal ;
 Sea's Sov'reigness, Sleep-bringer, Pilgrim's Guide,
 Nocturnal Queen : What shall I say beside ?
 By th' Influence the Sea doth ebb and flow,
 As thou, th' horn'd Queen, dost either shrink or grow.
 Yet of thy self thou hast no innate Light,
 But what thou get'st from *Titan's* Beams most bright.

§. 1. Of the SUN's Cycle.

THIS Circle makes its periodical Revolution in 28 Years ; and was invented principally, thereby to know the true Order of the *Dominical* or *Sunday-Letter* for any Year.

To find this Number for any Year.

Rule. Add 9 to the Year given (for when Christ was born, this Number was 9,) and divide that Sum by 28, the Quotient tells us how many Revolutions this Circle has made since the Birth of our Saviour, and the Remainder is the Circle of the Sun for the Year required.

Exam. What is the Sun's Circle for the Year 1732 ?
 $1732 + 9 = 1741$; which divided by 28, quotes 61 Circles ; and the Remainder 5 is the Circle of the Sun for the Year 1732.

2. Of the Prime or Golden Number.

THIS Circle makes its Revolution in 19 Years ; in which time all the Lunations and Aspects between the Sun and Moon do nearly return to the same Place they were at 19 Years before.

To find this Number for any Year.

Rule. Add 1 to the Year (for when Christ was born, this Number was 1,) and divide the Sum by 19 ; the Quotient shews you, how many Circles of the Prime is made ; and the Remainder is the Prime for that Year.

Example. What's the Prime for the Year 1732 ?

Coasting Navigation

$1732 + 1 = 1733$; and this divided by 19, Quotient 91, and the Remainder 4 is the Prime required.

3. Of the E P A C T.

THE E P A C T is a Number never exceeding 30 (or the Moon's Age,) and is the difference between the Sun's Year of 365 Days, and the Moon's Year - 354 Days, *viz.* 11 Days; from whence, as an additional Supply, the Epact takes its Name.

To find this Number for any Year.

Rule. Multiply the Prime (before found) by 11; and divide the Product by 30; the Remainder, after Division, is the Epact.

Example. What's the Epact for the Year 1732, Prime being 4?

$4 \times 11 = 44$; which $\div$ by 30, the Remainder, after Division, is 14, the Epact required.

4. To find the Moon's Age at any time.

Rule. To the Epact (before found) add the Day of the Month, and the Number of Months from March (which are these; Jan. 0. Feb. 2. Mar. 1. Apr. 2. May 3. June 4. July 5. Aug. 6. Sept. 8. Octob. 8. Novemb. 10. Decemb. 10.) the Sum is the Moon's Age; But if the Sum exceed 30, subtract 30 therefrom; the Remainder is the Days of the Moon's Age.

Exam. What's the Moon's Age May 5, 1732?

Epact (before found) is 14 $+$ Mo. — Day 5 $+$ N^o. Mo. 3 = 22 Days, the Moon's Age required.

5. To find the time of the Moon's Culmination, coming to the Meridian; or the time when she comes to the South, vulgarly called, the Moon's Southing; which (with the Tides) differs each Day, in Time, 48 Minutes, or $\frac{1}{2}$ of an Hour.

Rule. Multiply the Moon's Age (before found) by 4; and divide that Product by 5; the Quotient is Hours; and the Remainder so many 12 Minutes of an Hour; and both together is her Southing.

Example. The Moon being 22 Days old, I demand at what time she comes to the South Part of the Meridian?

Note. If the Moon's Age exceeds 15 Days, reject 15, and work with the Remainder: For the Moon has the same Southing after the Full, as after the Change; that is, her Southing is the same at 16 Days Age as at 1, at 17 at 2, &c. There-

Therefore $22 - 15 = 7$ and $7 \times 4 = \frac{28}{5} = 5$, and 36 remains; which is 3×12 Minutes: So that the Moon's Southing is $5^h. 36^m$. which was required.

7. To find the time of full Sea at any Place, vulgarly called, To shift the Tides.

Rule. To the Moon's Southing (for the time given) add the Hours answering to the Point of the Compass, making full Sea (on the Full or Change of the Moon) at the Place proposed; the Sum is the time of full Sea, or High Water (after Noon) at the said Place.

Example. I demand the time of High Water (on the 5th of May, 1732) at Yarmouth?

The Moon's Southing (before found) is $5^h. 36^m$. and by our general Tide-Table, it flows at Yarmouth S.S.E. and N. N. W. on the Full and Change-Days; which is $10^h. 30^m$. in Time. Then $10^h. 30^m. + 5^h. 36^m. = 16^h. 06^m$. from Noon, viz. $4^h. 06^m$. in the Morning. (rejecting 12 Hours.)

7. To find how long time the Moon doth shine in the Evening, after the Sun is set; or in the Morning, before the Sun rises.

Rule. Multiply the Moon's Age by 48, and divide the Product by 60; the Quote is the Hours, and the Remainder the Minutes of Time of her shining: And this is when the Moon is less than 15 Days old. — But if the Moon be more than 15 Days old, subtract the time of her shining (found as before) from 24 Hours, and the Remainder will be the time of her shining in the Morning, before the Sun rises.

Exam. How long will the Moon shine upon the 5th day of May, 1732?

The Moon's Age (found as before) is 22, day. $\times 48 = 1056$; which $\div$ by 60, is $= 17^h. 36^m. - 24^h. 00^m. = 6^h. 04^m$. the time of her shining in the Morning before the Sun rises.

8. To find how many Signs and Degrees in the Zodiac the Moon is departed from the Sun, since the last Conjunction with him.

Rule. Multiply the Moon's Age by 2, and divide that Product by 5; the Quote will give the Number of Signs; and the Remainder, (if any be) every Unit thereof is 6 Degrees.

Exam. The Moon being 22 days old, how many Signs hath she departed from the Sun, since her last Conjunction, or New Moon?

$22 \times 2 = 44$; which $\div$ by 5, the Quote is 8 Signs and 4 remains; which is 24 Degrees: So that the Moon is departed from the Sun 8 Signs, and 24°.

To find the Moon's Place in the Zodiack, *vide* my *Comprehensive Treatise of Astronomy*.

Note, According to the Moon's distance from the Sun, is the Variation of her Phases, or Appearances: For she being a round, opaque, globular Body, and having always that Hemisphere of her that beholdeth the Sun enlighten'd, she must of necessity, as she moves round the Earth, changing her situation, both in respect of the Sun and us, have a different Appearance, by turning more or less of her illuminated Hemisphere towards us.

Her Phases are usually accounted Four, according to her four-fold Aspect; her Conjunction being esteemed none, seeing her enlightned Half is then wholly turned from us.

About the third day after the Conjunction, she emerges in the Evening out of the Sun's Rays, and turns a small part of her illuminated side towards us, beginning to appear sharply horned, her Horns looking backwards and tending towards the East: For *note*, that while she increaseth in Light, she followeth the Sun, and shineth after Sun-set, her enlightned Part looking into the West; but decreasing, she goeth before the Sun, and shineth before his Rising, her illuminated Part looking into the East. And when she comes to make about a sextile Aspect with the Sun, that is, about two Signs from the Sun, her first Face is called Horned: She makes her second Phase about the 7th or 8th day of her Age, being then about 90 Degrees, or at a square to the Sun, appearing half enlightned, or bisected. Afterwards coming to her Trine with the Sun, she appears Gibbous, turned or swell'd, which is her third Phase. Her fourth is, when in Opposition to the Sun, she appears wholly illuminated, which is called her Full. She makes the like Phases in her Decrease, but in a retrograde (or backward) Order.

Coasting Navigation.

10. Of a Year, and Kinds of Months.

A Common Year is $365\frac{1}{4}$ Days, (but more exactly, from Solar Observations, it is found to be 365 Days, 5 Hours, 49 Minutes, 4 Seconds.) And a Leap-Year (or Bissextile) 366 days.

A Month is either Solar, Lunar, or Civil. — The *Solar Month* is the space of time that the Sun is passing a Sign; that is, the $\frac{1}{12}$ of the Ecliptick, or 30 degrees; which is about 30 days: so that the Sun's Motion is about One Degree in a day; but (more exactly, the Sun moves in one day, $59^{\circ} 8' 19'' 43''' 47'''' 21''''' 29''''''$.)

The *Civil Month* is a space of time, more or less, according to the Pleasure of the Civil Magistrate, or Civil Power; and is, in our *Julian Calendar*, according to this Rhime;

Thirty days hath Fruit-bearing, *September*,
Moist *April*, hot *June*, and cold *November*;
Short *February* twenty eight alone.

The other Months each claims his thirty one;
But when of Leap-Year comes the time,
Then *February* hath twenty nine:
For *February*, when her fourth Year's run,
Does gain a Day from the travelling Sun.

The *Lunar Month* is either *Periodical* or *Synodical*.

The *Periodical Month* is 27 days, 7 hours, 43 minutes; being the space of time, in which the Moon passing from one Point of the Zodiack through the twelve Signs, returns to the same again.

The *Synodical Month* is about 29 days and half, the space of time between one Conjunction of the Sun and Moon and another.

Having not room here to treat at large of the *Julian* and *Gregorian* Kalendars, I shall only here briefly speak of them, and offer an Essay towards the Emendation of the *Julian*, which we account by,

The *Julian Account* derives its Name from the Emperor *Julius Caesar*, who about 38 Years before Christ, being instructed by expert Mathematicians from *Alexandria*, found the Year wanted 10 days, 6 hours *ferè* of the *Solar* or *Tropical Year* (it being then accounted but 355 days, from *Numa Pompilius*;) and by the Assistance

of *Sesigenes*, an able Astronomer, he (after the Conquest of *Pompey*) regulated the Year; adding the 10 days wanting to it, and made it consist of 365 days; which were divided into 12 Months, in the same manner as they are at this time: And lest the odd 6 Hours should create a Disorder in the Year afterwards, he order'd that every 4th Year one Day should be intercalated, or put into the Month of *February*, between the 24th and 25th days of that Month; in which, according to the *Roman* or old *Latin* Calendar, was called *Sext. Calend. Martii*, or the 6th of the Calends of *March*; and by the Interposition or Intercalation of this Day, there were two *Sext. Calend. Martii*; and the Word *Bis*, Latin for *Two*, being added to *Sext.* or *Sextilis*, it signified twice the Sextile, and made *Bissextilis*, or *Bissextile*, which is the Meaning and Formation of the Name: But we call it in *English* Leap-Year, probably from the *Dutch*, *Loop-jaar*; because it leaps beyond, or exceeds the Bounds of other Years by a Day.

And this is the state of our *Julian* Account, that has remain'd in use ever since some time before the Birth of our Saviour.

Now the *Gregorian*, or New Style, is that by which our Neighbours in most parts of *Europe* reckon. But our *Julian* Year, as aforesaid, being made up of 365 days, 6 hours, is greater than the true Solar Year, viz. of 365 days, 5 hours, 49'. 4". 21". by 10'. 55". 39". which although but a little time, yet in many Years makes a great Variation, amounting to a whole Day in a 132 Years, plus vel minus: For in 10'. 55". 39". are 39339". and in one day, or 24 hours are 518400". then divide 518400 by 39339", the Quotient is 132 Years, the space of time, in which we must necessarily lose one day, by our *Julian* Account. Now, if you divide 1732 by 132, the Quotient is 13 days, that we have lost in the *Julian* Account, since the Birth of our Saviour; thereby causing an apparent Anticipation of the Equinoxes and solstitial Points; insomuch that the Vernal Equinox, whose Place at the Council of *Nice*, Anno Dom. 324, was the 21st of *March*, is now, by Astronomical Observations, fled back to the 9th enter 10th of *March*; so that there has hapned to be two *Easters* in one Year, or within the Compass of 365 days; as it may still happen, reckoning by the old *Julian* Calendar: By which sometimes there are five Weeks difference between the Canon or Rule for it in the Common Prayer-Book and the Almanack; as it was in the Year 1663; and it

has differ'd a Week more than 20 times since the Year 1600 : And in the Years 2437, 2467, 2491 (if the World last so long) there will be an Error of 42 days ; and not long after that, of 49 days : And if this *Julian Account* remain in use till the Year 2698, it will never more happen according to the Rule of the Church. Nay farther, this is so erroneous, by the Retrogradation of the Equinox, that in process of time (if no Correction be made) *Christmas* will fall in *June*, and *Midsummer* in *December*.

In consideration of which, in the Year 1582, *Gregory* the 13th, being then Pope, by the Assistance of *Antonius Lilius*, his Brothers, and other eminent Mathematicians, set about regulating this Disorder, correcting the *Roman Kalendar*, appointing the Year should contain 365 days, 5 hours, 49 minutes, 12 seconds ; and that the Vernal Equinox, which was then on the 11th of *March*, should be brought up again to the 21st of *March*, as it was at the time of the first Council of *Nice*, *Anno Domini* 324. And to effect this, he order'd that 10 days should be left out of *October*, from the 5th to the 15th ; so that the 5th day of *October* was reckoned in the Kalendar for the 15th day of *October* that Year, 1582. And because the Sun still gains as he did before, those that go by the *Gregorian Account*, do still every Century or 100 Years (to reduce the Equinoxes one Day backward) reckon one Day sooner than before : So that now, since the Year 1700, till the Year 1800, they are 11 days before us, in the *Julian Account* : And therefore the First of *January* with us, is the 12th of *January* with them. And to retain the same Equinoxial Spring invariable upon the same Day, it was appointed at the said Emendation, that of 400 Years, the first, second and third Hundred, the Leap (Year) Day (which in the *Julian* falls in Course) should be omitted, and not intercalated, but on the 400th Year ; then the Leap-day should not be omitted, but reckon'd in : So that in 400 Years they thought fit to omit three Leap-years, and for Memory-sake, appointed the first Omission to be accounted from the Year 1600, not from 1582, in which the Reformation was made, because it was not only the Time in which the Emendation was begun, but also the Equinox had not made an Anticipation of 10 days from the Place thereof at the time of the *Nicene Council*, which was *March* 21.

The Years then 1700, 1800, 1900, which should have been Leap-years, are to be accounted common Years ; but the Year 2000 must be a Leap-year. In like man-

ner,

per, the Years 2100, 2200, 2300, shall be common Years, and the Year 2400 Bissextile, and so forward.

And although the *Gregorian* Account is not so perfect as it should be, being reduc'd no farther back than till the Council of *Nice*, about the Year 324 *post Christum*, and still wanted two Days of right; whereas it ought to have been reduced to the Time of Christ's Birth: yet the Quantity of the *Gregorian Year*, 365 Days, 5 Hours, 49 Minutes, 4 Seconds, 21 Thirds, agrees better with the Heavenly Motion, and the Equinoxes and Solstices are more firmly fixed by it, and *Easter* celebrated more according to the Direction and Mind of the *Nicene* Council, than by the *Julian* Account of 365 Days, 6 Hours; and therefore does, and will bear away the Garland from it, and makes it be esteem'd a Stranger to Truth.

It is therefore to be wish'd, that a Reformation may be made in our old and erroneous Calendar (in this Nation, so flourishing in Arts and Sciences, not inferior to any in the World for Polity, Arms and Learning) towards which I shall humbly offer what follows, *viz.*

The main Reason (as I take it) against an Emendation in this Nation, is, the Confusion that would follow about the Dates of our Civil Contracts, as Bonds, Deeds, Payments of Rents, &c. To which I answer, That if we cannot be prevailed with to agree with the Pope's Method of cutting off 13 Days in some Month, yet Publick Authority might direct, that the odd Days, *viz.* one Day in the Months of *January, March, May, July, August, October, December*, each consisting of 31 Days, may be omitted for two years, except in one of the Months; or at least, that all Leap-years were omitted but 12 years; that alone would gradually and insensibly, without the least Inconveniency, bring us Two days before the *Gregorian*, and be agreeable to the Sun's Place at our Saviour's Nativity: Whereas the *Roman* Account, being reduced to the Council of *Nice*, would be Two days less exact. And if after that, the Bissextiles be kept as before, except in every 132d Year, wherein a Leap-Day must be exempted for ever; or else, that one Leap-year be struck off every 1000th Year, except in each 400th Year, for ever; there would need no more to have our Festivals kept according to Primitive Observation: For by supposing the Tropical Year to be as aforesaid, (according to *Bullialdus*) 365 days, 5 hours, 49 minutes, 4 seconds, 21 thirds, the Annual Redundancy allow'd, it will

will be 10 minutes, 55 seconds, 39 thirds; which compleateth 1 Day in 132 Years, and but 2 minutes, 25 seconds, 48 thirds, over; and 3 Days in 400 Years with 51 minutes over, which makes but one Day in 11294 Years, and therefore very inconsiderable. But to return from this Digression (if it may be so thought) I proceed now, to find when it's Bissextile or Leap-Year.

Rule.

Divide the Year by 4, what's left shall be
For Leap-Year 0; for past 1, 2 or 3.

11. What's the Year 1732?

$\frac{1}{4}$ of 1732 is 433 Leap-Years since Christ's Nativity, and 0 remains, which shews it's the Leap-Year.

12. To find the Dominical or Sunday Letter.

The Dominical Letter is always one of these seven, viz. A 1, B 2, C 3, D 4, E 5, F 6, G 7, and doth shew Sunday in the Kalendar and Almanacks all the Year; to find which this is the Rule,

Divide the Year its 4th, and 4 by 7;
What's left, subtract from 7, the Letters given.

Example 1. What's the Dominical Letter for the Year 1731?

$1731 \div 4 = 432 + 3 = 1731$ which $\div$ by 7, the Remainder is 4. And $7 - 4 = 3$ or C, the Dominical Letter required.

Example 2. What's the Sunday-Letter for the year 1732, being Leap-year?

Note 1. When it is Leap-year, there are two Dominical Letters; one serves to the 25th of February, the other from thence to the year's End.

2. The Dominical Letter goeth backward in a common Year one Letter; but in Leap-year, two Letters.

3. The Leap-year having two Dominical Letters, it is the latter of them that is found by the Rule above.

$1732 \div 4 = 433$ which $\div$ by 7, the Remainder is 6. And $7 - 6 = 1$ or A; to which prefix the next Letter in order, B, it is BA, the Dominical Letters required.

13. To find the Dominicals, Sun's Circle, Prime, Epact, moveable Feasts, Eclipses, Moon's Age, Moon's Southing, her Setting, her Distance from the Sun, her Motion, Rising and Setting, and Time of High-Water at any Place, by Inspection in our Tables.

Example. January 12, Anno 1734. Table 1. The Dominical Letter is F. Sun's Circle, 7. the Prime, 6. Epact, 6. Shrove Sunday, Febr. 24. Easter Day, Apr. 14. White Sunday, June 2. And there are two Eclipses this year of the Sun, but both invisible to us, the 5th Central.

Table 3. Suppose the Moon chang'd Jan. 3, and 30—12—18 the Moon's Age Jan. 12. And the Moon's Southing is 2h. 24m.

Table 5. Moon's Age being 12 days, 'tis High-Water at London, Tinmouth, Hartlepool, Whitby, Dundee, Amsterdam, &c. at 11h. 48m. it flows Full and Change of the Moon in those Places N. B. b. N. and S. W. b. S. or 2h. 1. But at London 3h.

Table 2. The Moon being 12 Days old as before: She shines 9h. 36m. in the Evening after Sun-set. She is distant from the Sun, 4 Signs, 24 Degrees. — Her Motion is 55. : 8° : 7'. and her Rising and Setting as by the Table adjacent.

14. By knowing the Moon's Age, and the Time of High-Water in any Place; to find how it flows Full and Change of the Moon in that Place.

Rule. Subtract the Moon's Southing from the given Time of High-Water, (if you can: If not, add 12 Hours to the Moon's Southing and subtract;) and the Remainder shews the time answering the Point of the Compass, that makes full Sea, upon the Change or Full Days of the Moon.

Example. Admit I was at Bristol, and observ'd 'twas High-Water at 45 Minutes after 2 o'Clock; the Moon being 25 days old, or her Southing 8 hours: How does it flow there Full and Change of the Moon?

12h. + 2h. : 45m. = 14h. : 45'. — Moon Southing 8h. : ocm. is = 6h. : 45m. or E. b. S. and W. b. N. it flows there Full and Change of the Moon.

The Sea hath Firs, alternate Course she keeps,
 From Deep to Shore, and from the Shore to Deepes.
 Whether it were, that at the first the Ocean
 From God's own Hand receiv'd this double Motion,
 By Means whereof, it never resteth Stound,
 But (as a turning Whirly-gigg) goes round,
 Whirles of it self, and a good while after takes
 Strength of the Strength which the first Motion makes.
 Or whether *Cynthia*, that with changeful Laws
 Commands moist Bodies, doth this Motion cause:
 As on our Shore, we see the Sea to rise,
 Soon as the Moon begins to mount our Skies
 And when thro' Heav'n's Vault vailing toward *Spain*
 The Moon descendeth; then it ebbs again.
 Again, so soon as her inconstant Crown
 Begins to shine on th' other Horizon,
 It flows again: And then again it falls,
 When she doth light th' other Meridionals.

15. By having the Time of the first New Moon in January, all other Aspects of the Moon and Sun may be collected throughout the whole Year: Thus,

		Days.	ho.	'	"
For the	Jan. 1. The Moon being New or in ☿, her Age —	00 : 00 : 00 : 00			
	{ Sextile Aspect * take	04 : 22 : 07 : 20			
	{ First Square □	07 : 09 : 11 : 01			
	{ Triangle Aspect △	09 : 20 : 14 : 41			
	{ Full Moon or ☿ Opposition	14 : 18 : 22 : 02			
	{ Full Moon's Triangle △	19 : 18 : 22 : 02			
	{ Second Square □	22 : 03 : 33 : 02			
	{ Second Sextile * —	24 : 14 : 36 : 42			
	{ Other New Moon ☿ or Con-junction — —	29 : 12 : 44 : 03			

When the Moon becomes visible after she is in Con-junction with the Sun, then she makes her Effects mani-fest.

Whence this Proverb;

As is the fourth and fifth Day's Weather,
So's that Lunation altogether.

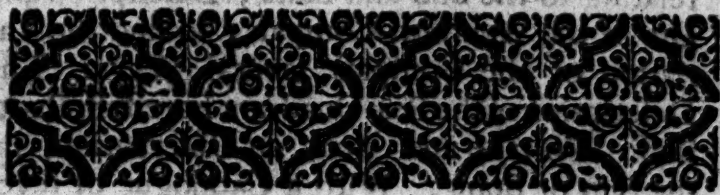
Or thus, the Noble Lord DUBARTUS.

By Sol's Aspect, her own she daily makes,
She Wax-less, Wane-less, doth both wain and wax.
And, tho' to us she seem a Semi-Ray,
Her full round Face doth never fall away.
By his fair Beams, as well by Day as Night,
The full whole half of her thick Orb is bright.
And as she draws near or far-off from him,
So more or less our half is clear or dim.
Her upper-half is full in her Coition,
Her lower-half is in her Opposition;
Her other Quarters other Form express,
And up or downwards shew her more or less.
When we see little, then the Heav'ns have store;
When Heavens see little, then have we the more:
Nearer the Sun, the less she seems in Sight,
Turning her Horn still t' her Opposite.
At Evening increasing she the Sun succeeds,
At Morn decreasing, she her Car preceeds.
So that each Month the Sun environs her,
On every Side his Splendor to confer.
Her Silver Light then only faileth her,
When the Earth's between them (in Diameter)
Which hides her Beauty with a sable Cloud,
From Light of him her Brother, Golden-brow'd.
Good Lord! What Changes dost thou work by these
Varieties, in Air, in Earth or Seas.
Fair or foul Weather, Wind, or Wet, or Thunder,
To dry, or drip, or cold, or warm her-under.
If she but smile the fourth Day 'twill be fair,
If then she blush, we shall have blust'ring Air:
If then her Brows be muffled with a Frown,
Most of that Month shall sad tears trickle down.
Thus doth the Vigour of the Signs superior,
Rule in the Virtues of the Things inferior:
But all are govern'd by God's Sov'reign Might,
O! happy he who understands it right.

For the Courses and Distances from Place to Place in Coasting, Sailing into Harbours, &c. See the *Coasting Pilots*, sold by the AUTHOR and Proprietors of this Book; Corrected by the latest and best Observations: And all other Mathematical Books and Instruments at the lowest Prices.

N. B. It is found by Observation, that the Tide comes to the Meridian of each respective Port about 3 Hours after the Moon: The Reason of which, you may see in Sir Isaac Newton's *Math. Philosophy*, Lect. 37, and 38. But this is to be understood of Ports that are upon the Main Ocean: For where it is transmitted thro' Streights and Channels, the Motion is retarded; as all high Winds, Land-Floods, Moon's Latitude, &c. will cause some Alteration of the Times; but our General Tide-Table will give the Mean Time.





The COMPLETE
Modern Navigator's Tutor:
OR,
NAVIGATION
IN ITS
THEORY and CURIOSITY.

PART II.

Teaching in a

Plain, concise, and regular METHOD,
to solve all the Cases in Plain Sailing; Tra-
verse, Mercator's, Sailing, Parallel and Middle
Latitude, Sailing; Oblique Plain Sailing, (and
in Sailing or turning to Windward, in a Cur-
rent or Tide's Way;) Geometrical, Trigon-
ometrical, Arithmetical, Instrumental, and by
Inspection in Tables; together with the Con-
struction and Use of the Plain and Mercator's
Charts, the Practical Problems in ASTRONOMY,
relating

relating to the Sun and Stars ; Description and Use of the Azimuth-Compass ; to find the Variation of the Compass several Ways : The Description of the Sea-Quadrant Forestaff, Backstaff. To take and work an Observation, by the Sun or Stars : With a Catalogue of several eminent Stars, coming to the Meridian throughout the Year ; the Description and the Use of the Nocturnal, in finding the Latitude by the Pole-Star, &c.

CHAP. I.

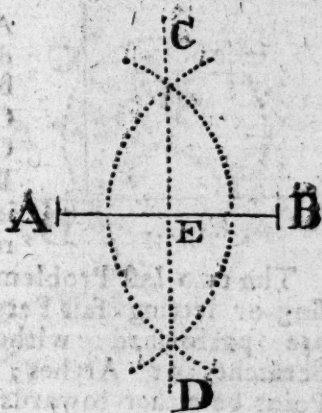
THEORETICAL NAVIGATION.



THE proper great or foreign *Navigation*, or the Art of Traversing and Caravanning over NEPTUNE's vast Dominions, is not a simple or single Science ; but a Complication of the three most noble Liberal Sciences, viz. *Arithmetick*, *Geometry*, and *Astronomy*. It makes Use of *Arithmetick* for Computation or Calculation ; *Geometry* for Delineation and Demonstration ; and *Astronomy* for Observation. For the first of these I shall only here begin with a few necessary *Geometrical* Problems, and the Elements of Plain *Trigonometry*.

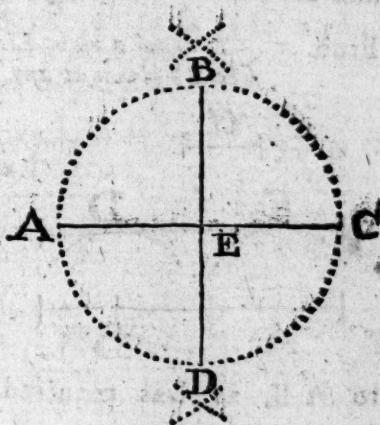
Prob. I. To bisect or divide a Line, as A B into two equal Parts.

Construction. Set one Foot of the Compasses in A, and with any Extent above half the given Line strike two small Arches, the one above, and the other below, as C and D; then with the same Extent setting one Foot in B, cross the two former Arches in C and D; then draw the Line C D which will divide A B into two equal Parts in the Point E, as was to be done.



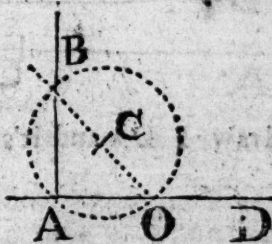
Prob. 2. To cross a Circle at right Angles or to quarter a Circle, as A B C D.

1. Thro' the Center E draw a Diameter A C.
2. Divide the Diameter or Line A C into two equal Parts by the last Problem, and it's done.



Prob 3. From a Point in a given Line either in the Middle or End thereof to raise or erect a Perpendicular. Let A D be a Line given, and A the Point assigned.

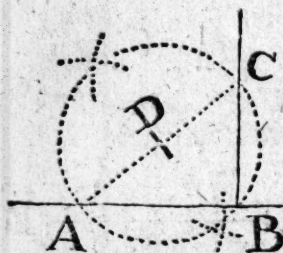
Construction. Fix one Foot of the Compasses on any convenient Point as C, extending the other to A, then turning them, with that Foot at A make an Arch at B, and another at O to cross the Line A B: Then lay a Ruler over O and C, and draw a Line, cutting the Arch B in B. Lastly, draw A B, which will be a Perpendicular W.W.R.



C

Prob.

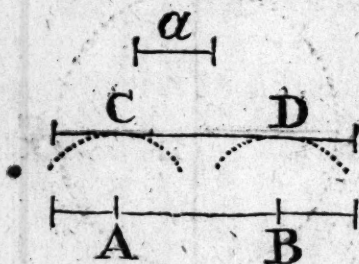
Problem 4. From a Point aloft (as C) to let fall a Perpendicular upon a given Line (as A B) is proposed.



Const. From C, draw a Line C A, (cutting A B in A) which Line divide into two equal Parts in E by Prob. 1. Then one Foot of the Compasses in E, at the Extent D C or D A, describe an Arch C B. Lastly, Draw C B, which is the Perpendicular required.

The two last Problems are the best Methods for raising or letting fall Perpendiculars; forasmuch as they are performed without making many, or long Scratches or Arches; and they hold, let the given Point be either towards the Middle or End of the Line, and are sufficient for any Use.

Prob. 5. To draw a right Line C D parallel to a right Line (A B) given at any Distance (a) assigned.



Const. With the assigned Distance (a) setting one Foot in A, describe the Arch A; describe the Arch C; again, setting one Foot in B, describe the Arch D. Lastly, draw a Line to touch the Tops of these Arches as CD, which is the parallel Line

to A B, as was required.

Prob. 6. To draw a right Line (B D) parallel to a right Line (A C) given, that shall pass thro' a given Point B.



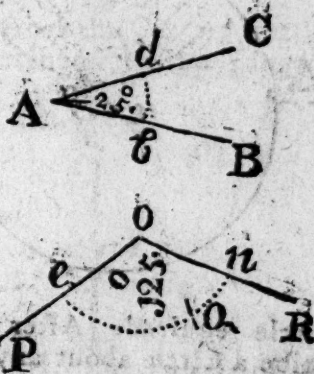
Const. Take the Distance B A, and setting one Foot in C, describe the Arch D; then with the Extent A C, and one Foot in B, cross the Arch D, in D; then

draw B D, and it's the Parallel required.

Prob. 7. To set off or describe any plain Angle, as suppose an acute Angle of 35° , and an obtuse Angle of 125° , is required.

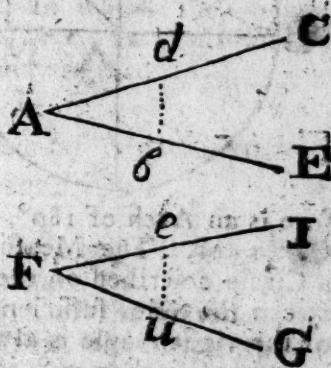
Const. 1. Draw the Line AB, and with a Chord of 60° , and one Foot in A, describe an Arch $b d$; make $b d$ equal to the Chord of 35° , and draw the Lines A, d, C, and it's the acute Angle required.

2. Draw the Line PO, and with a Sweep (or Chord) of 60° , and one Foot in O describe an Arch e, n ; then set of a Quadrant, or Chord off 90° from e to Q on this Arch, and the Residue, viz. the Chord of 35° from Q to n , and draw the Line O, R, which forms the obtuse Angle POR, equal to 125° as was requir'd.



Prob. 8. To make an Angle (as suppose GFL,) equal to an Angle (EAC given.

Const. Setting one Foot in the angular Point A, with any Extent as A d, describe the Arch b, d ; then with the same Extent setting one Foot in F describe an Arch e, e . Lastly, Take the Extent $b d$, and prick it from e to e , and draw FI which shall make an Angle equal to the Angle CAE as was to be done.



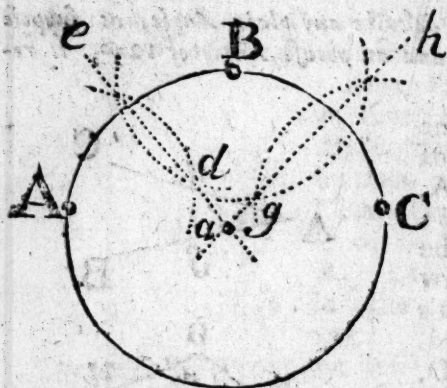
Prob. 9. To describe the Circumference of a Circle that shall pass through any three Points not situate in a right Line.

Construction. Suppose A B C, to be the three Points.

1. Take more than half the Distance A B, and with one Foot in A sweep an Arch; then with the same Distance, and one Foot in B, draw another Arch to cross the aforesaid Arch in the Points d and e . Secondly, With

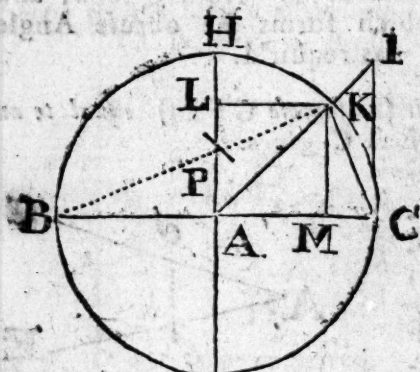
C 2

With more than half the Distance B C, and one Foot



in B, draw the Arch gh , and with the same Distance, and one Foot in C, draw an Arch to cross the aforesaid Arch in the Points g and h . Then, *Thirdly*, draw the Lines ed , a , and bg , and where these Lines cross, or intersect each other, as at a , is the Center of the

Circle required. After the same manner, you may describe a Circle about any Triangle.



The $\frac{1}{360}$ Part of the Circumference of a Circle is called a Degree, each of which is again subdivided into sixty equal Parts called *Minutes*; each of which again is imagined to be divided into 60 equal Parts, called *Seconds*. &c. to *Tenths*.

Therefore is an Arch of 180° , and a Quadrant or $\frac{1}{4}$ Part of a Circle 90° . The Measure of an Angle is the Arch of a Circle described on the angular Point, intercepted between the Sides sufficiently produced: So the Measure of the right Angle is always 90° , and the Angle which contains less than 90° , is called an *acute Angle*, but that which is more than 90° , is called *obtuse*.

The Proportion, which the Arches (being the Measures of Angles) have to the Sides of a Triangle, cannot be certainly known, unless by a comparing of Arches with their terminating straight Lines, as Chords, Sines, Tangents, Half Tangents, Secants, and versed Sines.

A Chord is a right Line subtending an Arch as C K.
A Sine is half the Chord of the double Arch as K M.



A Tangent is a Line touching the Circle in some Point, as I C.

The Semi-Tangent is not half the Tangent of an Arch, as some take it to be, but is the Tangent of the half Arch, as A P.

The Secant is a Line drawn from the Center, cutting the Circumference, and is extended to the Tangent Line; as A I.

Let K C be an Arch of 45° then

K C is the Chord

K M is the right Sine

M A = L K the Co-Sine

M C is the versed Sine

C I the Tangent

H I the Co-Tangent

A P the Semi-Tangent

A K = A C = H A = B A = C I, the Sweep of the Circle, called the Radius, or Semi-diameter. *Note*, that the Secant of 60 is equal to the double Radius.

Such Proportion as the Circumference of one Circle has to another, such proportion have their Degrees, Semi-diameters, Sines, &c. of like Arches one to another, and the contrary.

Assigning the Radius A C to be a Unit with Cyphers at Pleasure, to express the Quantities of these respective Lines in relation to the Arches to which they belong, is to make a Table of *natural Sines*, Tangents, and Secants, which I have not room here to treat of.

2. The Elements or Principles of TRIGONOMETRY Rectilinear.

And 1. **T**RIGONOMETRY is a Greek Word, which signifies the Measure of Triangles; a Science so necessary to most Parts of the Mathematicks, and in particular to NAVIGATION, that without it no Man can be an Artist, or deserve the Name of Learned in the Mathematical Sciences.

Definitions

1. The Inclination of two right Lines meeting or cutting each other, is called a plain Angle.

2. That an Angle is said to be greater or less than another, according as the said Arch contains more or less of the equal Parts which that Circumference is divided into.

C 3

3: A

3. A plain Surface, terminated by three right Lines, is called a plain Triangle.

4. Triangles are either Right or Oblique angled.

5. The Triangle that has one Angle 90° (or a Perpendicular raised or let fall in it) is called a right-angled Triangle.

6. The Triangle that has no Angle 90° , (or Right-Angle) is an oblique-angled Triangle.

7. A plain Triangle has 6 Parts, *viz.* 3 Sides, and 3 Angles; whereof any three being given (except the Angles) the other three may be found.

LEMMA.

In all plain Triangles, the Sum of the three Angles is equal to a Semicircle, or 180° .

COROLLARY 1.

Whence in a right-angled plain Triangle, because the right Angle is always 90° , the Sum of the other two Angles is also 90° ; and therefore subtract the acute Angle given from 90° , the remainder is the other acute Angle.

COROLL. 2.

In any oblique plain Triangle, having two Angles given, their Sum subtracted from 180 , is the other Angle required.

Prop. 1. *Given opposite Sides and Angles.*

Rule of Sines.

1. As any one Side is to the Sine of its opposite Angle; so is any other Side to the Sine of its opposite Angle.

2. As the Sine of any one Angle is to its opposite Side: so is the Sine of any other Angle to its opposite Side.

Note; If an Angle be required, let the Proportion begin with a Side: But if a Side be required, then begin with an Angle.

Prop. 2. *Given two Sides, and the contained Angle.*

Case 1. If in right-angled Triangles, (as in *Case 6*, of *Plain Sailing*.)

Rule 1.

Rule 1. Of TANGENTS.

As one Side is to Radius, or Tangent 45° ; so is the other Side to the Tangent of its opposite Angle.

Note; If an Angle be required, let the Proportion begin with a Side: But if a Side be required, then begin with the Radius.

Case 2. If in oblique-angled Triangles.

Rule 2. Of TANGENTS.

As the Sum of the Sides, containing any Angle, is to their Difference; so is the Tang. of $\frac{1}{2}$ the Sum of the unknown Angles, to the Tang. of $\frac{1}{2}$ their Difference.

Then $\frac{1}{2}$ the Difference, added to the $\frac{1}{2}$ Sum, is the greater Angle required. And the $\frac{1}{2}$ Difference subtracted from the $\frac{1}{2}$ Sum is the lesser Angle required.

Prop. 3. Given the three Sides.

Rule. As the Base, or longest Side, is to the Sum of the other Sides; so is the Difference of those Sides, to the Difference of the Segments of the Base.

Then $\frac{1}{2}$ the Difference, added to $\frac{1}{2}$ the Base, is the Base of the greater right-angled Triangle; and $\frac{1}{2}$ the Difference, subtracted from $\frac{1}{2}$ the Base, is the Base of the lesser right-angled Triangle. Whence you have enough given to find what is required by *Proposition 1.*

From these three Propositions, or Canons, Proportions are easily formed, for all the Cases that can happen in plain Sailing, Traverse, oblique, and *Mercator's* Sailing, as shall be shewn.

But first, to find the Logarithm of any Number, (Suppose 74 Miles, Leagues, &c.) look under Title *N.* (for Number) in the Table of Logar. N^o 6. for 74; against it on the Right hand is (1,869231) the Logarithm sought; *Et contra*, to find the Number of Miles answering to any Logarithm (when wrought) as suppose this, 1,897627. Look for these Figures in the aforesaid Tables, and against them on the Left-hand stands 79, the Miles, Leagues, &c. sought.

2. To find the Sine, Tangent, or Secant of any Degrees and Minutes.

Suppose of 34° . Look in the Table (N^o 6.) for 34 D. on the Left-hand, and against it, on the Right-hand, stands Natural Sine, 55919, Nat. Tang. 67451, Nat. Secant 12622; Logarithmet. Sine 9.74561, Log. Tang. 9.828987, Log. Secant.

Secant. 10.081526. & contra To find the Degrees answering to any Natural or Logarithm-Sine, Tangent, or Secant, seek the nearest Figures in the Table under its proper Title; and on the Left-hand you have the correspondent Degrees. The same is to be understood of Points and Quarter-points of the Compass in the next Table, the Literal Figures being the whole Points, and the Numerical Figures quarters of a Point.

3. To work a Proportion or Canon, by the Logarithms, Sines or Tangents, observe this general Rule for the artificial ones, viz.

Add the Logarithm. of the second and third
From the Sum subtract the Logar. of the first
The Remainder is the Logar. of the fourth

} Term.

4. To work a Canon or Proportion by Gunter's Scale.

General Rule.

The Extent of the Compasses from the first to the
 { second } will reach { third } to the fourth
 { third } from the { second } Term required.

Note, If there be a Tangent in the Proportion then the Radius is the Tangent of 45° . and when there is a Secant mention'd, the Operation cannot be perform'd by the Scale.

These things being premised, I shall proceed to shew the General Axiom, viz.

In all Right-angled plain Triangles, if one side be made the Radius (or Sweep of a Circle) the other Sides will be Sines, Sine-Complements, Tangents or Secants; as is evident from the Diagram-Page foregoing; for suppose in the Diagram the Triangle AIC, here the Side AC is Radius, and the Angle at A 50° , The Side CI is Radius, and the Angle at A 50° . The Side AI the Tangent of 50° and the Hypotenuse A Q I is the Secant of 50° . and what Proportion the Radius hath to the Side A C, the same Proportion hath the Tangent of 50° to the Side C I; and the same Proportion hath the Secant of 50° to the Hypotenuse AI.

Again, if you make the Hypotenuse the Radius, and suppose the Angle at A 50° as before; then in the Diagram it is represented by the Triangle A M K, and then

the Side MK is the Sine of the Angle at A ; and the Side AM equal to LK is the Sine Complement (to 90° .) of the Angle A ; and then what Proportion the Hypoth. hath to Rad. the same Proportion will the Side KM have to the Sine of 50° .; and the same Proportion will the Side AM have to the Sine Comp. of 50° , &c. And from this Proportion proceeds Prop. foregoing. The Application of all which we come now to shew in Navigation.

General Definitions and Primary Rules.

I. **N**AVIGATION is an Art that teaches how to conduct a Ship through the Pathless Ocean (where nothing is seen for several Days but Sky and Water) from one Port or Place to another, the shortest Way, and in the shortest Time possible, to any part of the known World; or briefly,

NAVIGATION is an Art that teacheth thee
To direct a Ship through the untrack'd Sea,
To any Port or Place where e'er it be.

Navigation may therefore be divided into two General Branches, or Parts, viz. Domestick, or Home-Navigation; which is the Coasting or Sailing along Shoar, in Places not far distant, and in sight or Soundings, as between England, Holland, France, &c. for the Performance of which there is required the Compass, the Sounding-Lead, and Line, with a competent Knowledge of the Nature of the Lands, or Coast, the Soundings, Sands, Shoals, Rocks, &c. with the Knowledge of the Setting, Flux and Reflux of the Tides, (of which I have treated before).

2. Remote; which more properly is called Navigation, is that whereby the industrious Mariner directs the Ship to any Port in the habitable World, and knoweth at any time, in what Place the Ship is in, in respect to Latitude, Longitude, Course, or Distance; the Instruments that are used in this Art are, therefore, of two sorts, viz.

1. A pair of Compasses,
A plain Scale,
A Gunter's Scale.
The plain and Mercator's,
(or Wright's) Charts,

} for Operation.

1. A

2. A plain (or common) Compass,

An Azimuth-Compass,

A Sea Quadrant,

A Fore-staff,

An Almicut's Staff,

A Log and Line and $\frac{1}{2}$ Min. Glass,

} for Observa-
tion.

That is, the Instruments for directing and measuring the Ship's Way and Course steered; such as the Log and Line, and $\frac{1}{2}$ Minute Glass and Compass. Secondly, Instruments for Celestial Observation, such as the Quadrant, Fore-staff, Azimuth, or Amplitude-Compass, to measure the Heights, Distances, Azimuths and Amplitudes of the Sun and Stars, and finding the alteration, or Difference of Latitude, thereby to correct the Reckoning by Account, commonly call'd the Dead Reckoning; when there hath been any Error contracted either in the Course steer'd, or the Distance sail'd; Likewise Charts for pricking down the Ship's Way and Place; which gives a lively Representation where the Ship is at any Time. Thirdly, A competent Knowledge of the Nature of Currents, and of the Trim and Mould of the Ship, and the Sail she bears, Drift, Growth or Surge of the Sea, that so due Allowance may be made for Lee-Way, and other Impediments. 4thly, Skill in the Navigator; so that by the Help of these, he may be able to know at all times the Place the Ship is in, how far she hath to sail, and which way, and upon what Point of the Compass her Course is to gain her intended Port.

For the obtaining of which, the Mariner hath generally these things given;

1. The Latitude and Longitude both of the Place he is to sail from, and bound to, found in the Tables of Latit. and Longit. of Places, by the Help of which may be found (by the first Case of Mercator's Sailing) upon what Course, and how far the Ship must sail.

The Way obtain'd by the Log and Compass.

2. The Latitude of the Place the Ship is in by Observation taken with a Quadrant or Fore-staff; the Height of the Pole, by the Altitude or Distance from the Zenith of the Sun or a Star.

How to order and manage these, so as to produce the necessary *Quæstæ*, we come now to shew.

A Scheme or Projection of the Meridians or Parallels of the Globe in Plano, exhibiting how Latitude and Longitude is accounted.



Explanation.

Let the Circle ENQS represent the Compass of the terraqueous Globe; and let N be the North-point or Pole; S the South Pole; the Circle NQSN the General Meridian; and let NS, one Diameter, represent the first Meridian passing over London; and imagine a Line to begin this Globe round equi-distant from the North and South Poles, as EQ, it's called the (Equinoctial or) Equator. Again, imagine Circles to pass from one Pole to the other through as many Degrees or Points of the Equinoctial as you please, as N 10° S, N 30° S, &c. these Circles are called Meridians, upon which Latitude is accounted from the Equator both ways, to the North and South Poles to 90, and the Circles 10, 10 20, 20, 30, 30. parallel to the Equator, are called Parallels of Latitude. On the Equator we count the Longitude, from the Center C, (representing the first Meridian or London) increasing Easterly 180°, and Westerly 180°, from the said Meridian, till the Account ends in the opposite Meridian, on the other side of the Globe.

The

The Distance of any one Place from another is the shortest Line intercepted between these two Places, upon the surface of the Earth: Hence then, as the terraqueous Globe is a round Body or spherical (as I have elsewhere demonstrated) all Lines drawn upon the Surface thereof must be spherical, or Arches of a Circle, and therefore the Distance between any two Places must always be an Arch of a Circle; tho' indeed a small Part of our Globe, (it being of so great a Magnitude in the whole) differs not to our sense from a Plain, and the Distances of two Places not far distant, as a Right-line.

Observation 1.

Nature herself has placed no particular Beginning or Term of the Earth's Extension from West to East, or from East to West, (or according to the Equator) hence any of the Meridians may be taken for the first Meridian or Beginning of Longitude. Every *Superficies*, whether plain or curved, is determined and measured by two Divisions, or Extensions; of which Extensions, the one is called the Length or Longitude of that Figure, or *Superficies*, and the other the Breadth or Latitude thereof; but the Figure of the Earth being spherical, the Dimensions thereof are equal; and so the Length and Breadth, or Latitude and Longitude must not differ, but only according to our Conceptions, that these two Terms may be more obvious to us: For seeing that the Meridians do all meet in the Poles of the Earth, which are always a *Semicircle*, or 180° asunder from each other, this *Semicircle* we will take for one of the Earth's Dimensions. And seeing the Equator, equi-distant every where from these two Poles, is continued without interruption, to a whole Circle (or 360°) we will take this for the other Dimension of this spherical Surface; this being a whole Circle, is longer than the other, being only a $\frac{1}{2}$ Circle; therefore the Equator must be the Measure of the Earth's Length or Longitude, and the Meridian the Measure of its Breadth, or Latitude.

Observation 2.

The Circle you see in a clear Day, where the Sky and Sea seems to meet all round, is called the sensible or visible Horizon; parallel to which, at the Distance of the Earth's $\frac{1}{2}$ Diameter, is the true Horizon.

3. The Point in the Heavens directly over your Head, in all Places is called the *Zenith*; and the Point under the Feet is called the *Nadir*, and are each of them 90° . from the Horizon.

Now, if we imagine Circles to be described in the Heavens round the Globe, all meeting in the Zenith and Nadir, as the Meridians do in the Poles, and to cut the Horizon at right Angles, as the Meridians do the Equinoctial,

These Circles are called Azimuths, in which the Sun is every Minute of the Day, except at Noon when he is on the Meridian.

4. And if there be imagined Parallels to the Horizon upwards towards the Zenith, they are called Almican- ters, or Circles of Altitude, or Height of the Sun and Stars above the Horizon.

5. Amplitude of the Sun or Stars is their Distance from the East Point of the Horizon to the Northward of their Rising, and from the West Point, Northerly or Southerly at their Setting; according as the Sun or Star is to the Northward or Southward of the Equinoctial.

Of Course.

The Rhumb, or Course, is the Point of the Compass which a Ship sails on, reckoned from the North and South towards the East or West; and the Complement of the Course is the Point of the Compass steered, reckoned from the East and West, towards the North or South, or the Residue, (or Complement) of the Course, when taken from 90° .

Of Distance.

Distance is the Number of Miles, or Leagues, the Ship sails upon any Course or Point of the Compass.

Of Difference of Latitude.

Difference, or Alteration of Latitude, is the Difference, between the Latitude sailed from, and the Latitude the Ship is come into.

Of Departure, or meridional Distance.

Departure, or meridional Distance, is the Number of Miles the Ship hath made East or West, from the Meridian (or North and South Line) she departed from.

Primary Problems.

Prob. 1. } Given the Latitude of two Places.
 } Requir'd the Difference of Latitude between
 } them.

Rule 1. If the two Places are on the same side of the Equator, (that is, both in North or both in South Latitude) their Difference is the Difference of Latitude required.

Rule 2. If the Places are on the contrary side of the Equator, (that is, one in the North, the other in South Latitude) their Sum is the Difference of Latitude.

Examp. 1. What's the Difference of Latitude between the Lizard and Madera?

From { the Lat. of } Lizard. $49^{\circ} : 36' \text{ N. } 17^{\circ} : 31'$
 Subt. { Madera $32 : 25 \text{ N. } 60$

Remaind. is the Diff. of Lat. $= 17 : 31$, or 1051. miles.

Examp. 2. What's the Difference of Lat. between St. Jago, one of the Isles of Cape de Verd, and St. Helena, an Island in the Ethiopian Sea?

To } Lat. { St. Jago $14^{\circ} : 56' \text{ N. } 30^{\circ} : 41'$
 Add } St. Helena $15 : 45 \text{ S. } 60$

The Sum is the Diff. Lat. $30 : 41$ or 1841 miles.

Prob. 2.

Given, One Latitude and Difference of Latit. Requir'd the other Latitude.

Rule 1. The Ship in N. Latitude.

1. If the Course be Northward, she raiseth, or elevateth the Pole, and increaseth her Latitude; and therefore the Difference of Latitude, (reduced to Degrees and Minutes) must be added to the Latitude from whence the Ship came, and that Sum shall be the Ship's Latitude North.

Examp. 1. Suppose from the Latitude of $32^{\circ} . 25'$ North, a Ship sails 1051 Miles or $17^{\circ} . 31'$ Northward, what's the Latitude the Ship is in?

To the departed	}	Lat. { 32 : 25 N.
Add the Difference of		17 : 31 N.
		49 : 56 N.
Sum is is the Latitude required		

Examp. 2. If from the Latitude 40°. 30'. North a Ship sails Southward till the Difference of Latitude be 25°. 15'. what Latitude is she in ?

From the departed	}	Lat. { 40 : 30 : N.
Subtract the Difference of		25 : 15 : S.
		15 : 15 : N.
Remainder is the required Latitude		

Note. If the Course be Southward, and the Difference of Latitude (reduced to D. and M.) is greater than the Latitude the Ship came from : subtract the said Latitude from the Difference of Latitude, and Remainder shall be the Ship's Latitude South ; and consequently the Ship hath cross'd the Equinoctial Line, and depressed the North Pole, and raised the South Pole.

Examp. 3. If from the Latitude of 2°. 20'. North, a Ship sails Southward till she has differ'd her Latitude 4°. 30', what Latitude is she in ?

From the Difference of	}	Lat. { 4 : 30 S.
Subtract the departed		2 : 20 N.
		2 : 10 S.
Remainder is the required Latitude		

Rule. 2. The Ship in South Latitude.

1. If the Course be Southward, the Ship raiseth the South Pole, or increaseth her Lat. and then the Diff. of Lat. reduc'd into D. and M. must be added to the Lat. she departed from, and the Sum shall be the Ship's Lat. South.

2. If the Course be Northward, she decreaseth her Lat. and therefore the Diff. of Lat. reduc'd to D. and M. must be subtracted from the Lat. she departed from, and the Remainder shall be the Ship's Latitude South.

Note,

Note. If the Course be Northward, and the Difference of Latitude be greater than the Latitude the Ship came from: subtract the said Latitude from the reduced Difference of Latitude, and the Remainder will be the Ship's Latitude North, and consequently the Ship hath crossed the Equinoctial.

Rule 3. To find whether you must sail Northward or Southward, between any two Places whose Latitudes are known.

1. If you sail from a greater North Latitude to a lesser, the Course is southward: But if from a lesser North Latitude to a greater, the Course is Northward.

2. If you sail from a greater South Latitude to a lesser, the Course is Northward: But if from a lesser South Latitude to a greater, the Course is Southward.

If you sail from a North Latitude to a South Latitude, the Course is Southward; but if from a South Latitude to a North Latitude, the Course is Northward.

If a Ship sails East or West, she keepeth in the same Latitude, and makes no Northing or Southing, but her Distance and Departure will be the same.

If a Ship sails North or South, she keeps in the same Longitude, and makes no Easting or Westing; therefore her Distance and Difference of Latitude is the same.

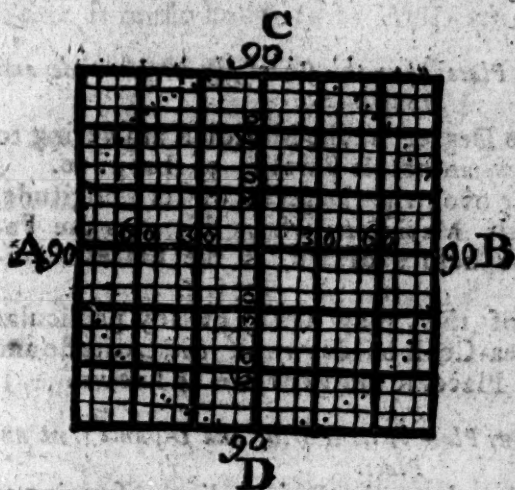
4. Of plain Sailing, and the plain Sea-Chart.

Plain Sailing shews the various Motion of a Ship on a Plain (Rectangular) where the Meridians are all made parallel to one another, the Parallels at right Angles to the Meridians, and the Degrees of each, parallel to those of the Equinoctial; in which, though according to this Hypothesis, each Parallel is falsely supposed equal to the Equator, and the terraqueous Globe as falsely to be plain or flat; yet since a small Part of the Earth's Superficies does differ very little from a Plain; if a Ship sail under or near the Meridian, or near the Equator, a short Voyage, or a long one cut into many short one's, may be tolerably well performed by it; therefore we shall proceed to it's Construction and Use.

Of the Construction of the plain Chart.

These Charts are either general or particular.

1. The general plain Chart.



Projection.

Draw the Line A B for the Equator; and divide it into 180 equal Parts or Degrees, and thro' each Degree, or (as here) each 10th Degree; draw perpendicular Lines which shall represent the Meridians of this Chart. Divide

these Meridians into 90 equal Parts or Degrees from the Equator, toward the Northward and Southward thereof and draw Lines parallel to the Equator, which shall represent the Parallels or Circles of Latitude, as the Meridians did represent the Circles of Longitude; upon this Chart then you may by help of a Table of Latitude and Longitude of Places insert the said Places.

But seeing (according to this Chart) that the Meridians have no Inclination to each other, but are all parallel to each other, and divided equally as the Equator; therefore if you insert these Places according to their true Latitudes and Longitudes, then shall their Course and Distance disagree with the Globe; and if you set these Places upon this Chart according to their Latitude and Distance, then will their Course be true, but their Longitude always erroneous, as shall be explained in the Use of Mercator's Charts.

2. The Construction of the particular plain Chart is the same with that of the general, and differs only in its Extent, and made generally for a small Part of the World; with one or more small Compass Cards, in the Middle or Corners, to shew by the Rhumbs, or Points of these, the Bearings or Position of Places, and also a Scale of Leagues for measuring the said Distances of Places; the Meridian is also a Scale of equal Degrees, and may serve likewise to measure the said Distances. Lastly, if each Degree of the Meridian is divided into as many equal

equal Parts as its Breadth will admit of, the Chart is render'd fit for any manner of Use that it may be applied to; and

1. *To lay down any Place upon this Chart, by its Latitude and Longitude.*

1. Through the Degree in the Meridian answering to its Latitude, draw an occult Parallel of Latitude.

2. Lay a Ruler over the Degrees of its Longitude, and draw an occult Meridian; where this cuts the Parallel of Latitude before drawn, is the Place required.

By the Help of this, may a Map of any particular Country, or the Sea-Coast be drawn, if the Latitude and Longitude of the Places it must contain be known.

2s *To lay down any Place by its Bearing and Distance from any Place.*

After having found out the Rhumb-line answering to the Bearing given, through the Place proposed, and parallel to the Rhumb, draw a Line and set off upon it (from the given Place) the Distance given in Leagues, or Parts of the graduated Meridian, and the Point thus found will be the Place required.

3. *If the Difference of Latitude and Bearing be given.*

Count the Difference of Latitude either Northward or Southward (as the Case requires) on the divided Meridian and from the given Latitude, draw the Parallel of Latitude passing thro' the same, and lay a Ruler over the place, and parallel to the Rhumb-line given; where it cuts the Parallel before drawn, it gives the Place required.

4. *If it be by the Distance and Difference of Latitude.*

Having drawn the Parallel as before (by the Help of the Difference of Latitude) take the Distance between the Points of the Compasses, and set one Foot in the Place given, and with the other cross the Parallel before drawn, and you will have the Place requir'd. There are other ways to lay down a Place, as by the Course and Departure, or by the Distance and Departure; which, as they are of no great Use, so to avoid Prolixity, I shall wave them, and judge it needless to illustrate these Propositions by Examples, since they are so plain and easy.

Note, Difference of Longitude, meridional Distance, Departure from the Meridian signify (in the plain Chart;

Chart) one and the same thing, and is the nearest Distance of any two Meridians; it sheweth how far one Place is to the Eastward or Westward of another.

Of the Use of the plain Chart, by Examples.

1. To find the Latitude of any Place in the Chart.

Ex. *What's the Latitude of the Lizard in England?*

1. Take the nearest Distance from the Lizard to any Parallel of Latitude, or East and West Line.

2. Lay that Distance (on the graduated Meridian) from the said Parallel, and the moveable Foot sheweth 50 Degrees North Latitude; because to the Northward of the Equinoctial. Do so for any other Place.

2. To find the meridional Distance or Difference of Longitude between any two Places in the Chart.

Ex. *What's the meridional Distance (or Westing) from the Lizard to Cape Finisterre?*

1. Take the nearest Distance from the Lizard to a Meridian, and moving the Compasses with one Foot on it, and the other perpendicular, till both Feet come to the Parallel of Cape Finisterre.

2. Then the Distance from the perpendicular Foot to Cape Finisterre, being measured on the Meridian, is 3 Degrees, or on the Scale of Leagues 60.

3. To find the Course or Bearing of one Place from another.

Ex. *I demand the Course from the Lizard to the Island Madera?*

1. Laying a Ruler's Edge on the Lizard and (the Middle of) Madera, and take the nearest Distance from the Center of any Compass to the Ruler.

2. Slide the Compasses along by the Ruler, keeping one Foot perpendicular to it, and it sheweth among the Rhumbs the Course to be S. S. W. half W. nearest from the first Place to the second.

4. To find the Distance of one Place from another.

1. Extend the Compasses from one Place to the other.

2. Apply this Distance to the Scale of Leagues, or to the graduated Meridian; the first sheweth the Distance in Leagues, the latter in Degrees: This is so plain and easy, it needs no Example.

5. *The Latitude the Ship is in, and her meridional Distance given; to find in the Chart where the Ship is.*

D 2

1. Lay

1. Lay of the Meridional Distance (according to its Nature, whether to the Eastward or Westward) from the Place (you sail'd) it's counted from; and then the nearest Distance from that to any Meridian must be kept in one Pair of Compasses.

2. With another Pair of Compasses, take the nearest Distance of the Latitude from any Parallel, or East and West-line.

3. Then move both Pair of Compasses perpendicular, one to the Meridian, the other on the Parallel, till both perpendicular Feet meet, and there is the Place in the Chart representing the Place of the Ship required.

By the Help of these Propositions, may the Mariner discover upon what Course (if possible) and how far he must sail, to arrive at his desired Port, as also to lay down his several Runnings, and thence find the several Places he arrives at in the end; and so be able to alter his Course, a new, in order to gain any Port in the shortest Time possible.

But, though this Way is very expeditious, and a natural Representation to the Mind; yet I would not advise the young Navigator to depend wholly upon it; but rather besides this, keep to his Account by Calculation, according to the Methods hereafter shewn; and then if at any Time his Curiosity shall lead him to examine how exact he has been, will be of great Use.

I proceed now to *Theoretical Navigation*, according to all the modern Methods or Improvements. Method the first shall be *Plain Sailing* projected Geometrically, and wrought by the Logarithm and Gunter's Scale.



CHAP. II.

Theoretical NAVIGATION.

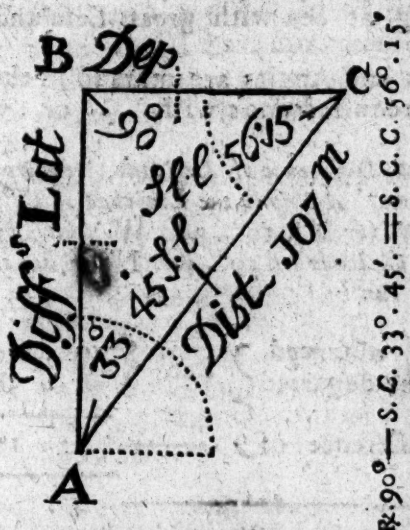
Plain-Sailing, METHOD I.

CASE I.

GIVEN Course and Distance; required *a.* Latitude and Departure: *A Ship in the Latitude of 45° , $30'$ N. sails N. E. $\frac{1}{2}$ N. 107 Miles, what Easting hath she made, and what Latitude is she come into?*

Pro.

Projection Geometrically.



1. Draw AB for a Meridian or North and South Line. 2. Make the Angle at A = 3 Points = $33^{\circ} : 45'$ from the Line of Rhumbs or Chords on your plain Scale, by *Prob. 7. Geom.* *Prob. (3.)* Draw AC, and make it equal to the Dist. 107. from any Scale of equal Parts. Lastly, From the Point C, let fall the Perpendicular CB, so shall AB be the Ship's Alteration or Difference of Latitude, and BC her Departure or Easting, $\angle A =$ Sine of the Course, and $\angle C$, the Sine-Complement of the Course, and $\angle B$ Radius $S. 90^{\circ}$.

tude, and BC her Departure or Easting, $\angle A =$ Sine of the Course, and $\angle C$, the Sine-Complement of the Course, and $\angle B$ Radius $S. 90^{\circ}$.

2. Mensuration mechanically.

AB, and BC being each measured on the Scale of equal Parts you set of AC by, the first gives 89m. for the Difference of Latitude, and 59m. for the Easting or Departure.

3. Operation Logarithmically.

1. As $R \dots$ Dist. $:: S. C. C. \dots x. Lat. Northerly,$
 $\text{--- } S. 90^{\circ} \text{--- } 107 m. \text{--- } S. 56^{\circ} 15' \text{--- } 89 m.$
2. As $R \dots$ Dist. $:: S. C. \dots$ Departure Easterly.
 $\text{--- } S. 90^{\circ} \text{--- } 107 m. \text{--- } S. 33^{\circ} 45' \text{--- } 59 \text{ Miles,}$

4. Instrumental by Gunter's Scale.

1. The Ext. } from { $R S. 90.$ to $S. C. C. 56^{\circ} 15'$ } the { Sines
will reach } to { Dist. 107' to Dist. Lat 89' } on { Nrs.
 2. The Ext. } from { $R S. 90^{\circ}$ to $S. C. 33^{\circ} 45'$ } the { Sines
reaches } to { Dist. 107' to Dep. 59' } on { Nrs.
- Lat. from $45^{\circ} 00' + x Lat. 1^{\circ} : 29 = Lat. in 46^{\circ} : 29,$
North.

Use or Practice of this first Case.

1. By this your Dead-reckoning is kept.

D 3

2 By

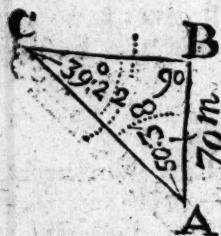
2. By it you may calculate the Table of Difference of Latitude and Departure; so very useful to work a Traverse, or Day's Log at Sea with great Ease and Quickness.

N. B. The given Sides and Angles are marked in the Projections with—; the required one's with . . . or : o

Case 2. Given, Course and Difference of Latitude, required Distance run and Departure. A Ship in the Latitude of $48^{\circ} 30'$ N. sails N. W. $\frac{1}{4}$ W. (or $N^{\circ} 50^{\circ} 38'$ W.) until by Observation, she is in the Latitude of $49^{\circ} 40'$ N. What is her Westing and Distance run?

Preparation; from the observed	} Lat. {	49 : 40
Take the departed		48 : 38
Remainder is the Difference of		1 : 10
From R — S —		90 : 00
Take the Sine of the Course —		50 : 38
Remains the Sine-Comp. of the Course		39 : 22

1. Geometrically.



1. Make $AB = 70$ from a Scale of equal Parts, and (by *Prob. 3. Geom.*) raise the Perpendicular BC .

2. Make the Angle at $A = 4 \frac{1}{2}$ Rhumbs, or $50^{\circ} 38'$ (the Course) from the Chords, and continue AC till it meet the Perpendicular in C . then is AC the Distance sailed, and BC the Westing or Departure. To measure which, apply AC to the same Scale of equal Parts, the first gives 110m. the Distance, the latter 85m. for the Westing or Departure.

3. Logarithmically.

1. As $S. C. C. \propto Lat. \therefore R. \dots$ Distance.
— $S. 39^{\circ} 22' — 70m. — S. 90^{\circ} — 110$ Miles.
2. As $S. C. C. \propto Lat. \therefore S. C. \dots$ Departure.
— $S. 39^{\circ} 22' — 70m. — S. 50^{\circ} 38' — 85m.$ Westing.

4. By Gunter's Scale.

The Ext. } from { S.C.C. $39^{\circ} 22'$ to R. S. 90° } on the { Sines
reaches } { x. Lat. 70m. to. Dists. 110 } { Nrs.
The Ext. } from { S.C.C. $39^{\circ} 22'$ to S.C. $50^{\circ} 38'$ } on the { Sns.
reaches } { x. Lat. 70m. to Depr. 85m. } { N 5.

Use. The Navigator must be sure to take an Observation by the Sun or Stars, as often as he has Opportunity, (every Noon and at Night,) and see that the Course be truly steered; and then if he finds the Difference of Latitude from Yesterday's Observation disagree from the Difference of Latitude by Dead-Reckoning, found by the first Case; then let him take the Course steer'd, and this observ'd Difference of Latitude, and find the (corrected) Distance and Departure by this second Case of Plain Sailing.

Case. 3. Given, Course and Departure: required Distance and Difference of Latitude.

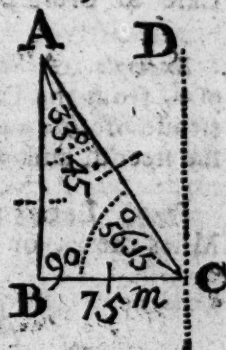
Ex. A Ship in the Latitude of $37^{\circ} 50'$ North, sails S. E. by S. until her Departure or Easting be 75 Miles; what is her Distance run, and the Latitude she is come into?

Geometrically.

1. Angle of the Course B A C being made equal to three Rhumbs or $33^{\circ} 45'$.

2. With the Departure 75m. draw D C parallel to the Meridian A B till it meet the Distance A C produced in C the Ship's Place.

3. From the Point C. let fall the Perpendicular B C.



2. Mensuration.

A C and A B measured on the equal Parts you protracted D C, shall give 134^m . the Distance.

Sailed, and _____ 112m.

$\frac{60}{\text{---}} = 1^{\circ} 52'$ the Ship's

Diff. Lat. Southerly.

3. *Logarithmically.*

1. As S. C. .. Depr. :: R. .. Dist.

— S. 33°.45' — 75m. — S. 90°. — 134 Miles.

2. As S. C. .. Dep. ; S. C. C. .. & Lat.

— S. $33^{\circ}.45'$ — 75^m . — $56^{\circ}.15'$. — 112 Miles.

4. *Instrumentally, by G. S.*

The Ext. } from { S. C. 33°. 45'. to R. S. 90°. } on { Sines
reaches } Dep. 75m. to Dist. 134m. } Nrs.

reaches } from { Dep. 75m. to Dist. 134m. } ° } Nrs.

The Ext reaches } from { S. C. $33^{\circ} 45'$ to S. C. $56^{\circ} 15'$ } on { Sns.
Dep^r, 75 m. to x. Lat. 112 m. } { Nrs.

reaches } from } Depr. 75m. to x. Lat. 112m. } ° } Nrs

From the Latitude sail'd from — 37 : 50 N°.
 Take the Diff's. Latitude — 1 : 52 Sly.

Remr. is the Ship's present Latitude 35 : 58 N°.

This Case is of little or no Use in Navigation.

Case 4. *Given Distance and x 's Latitude, requir'd Course and Departure.*

Example. A Ship sails between the South and West 98m. from the Latitude of 50° . 00'. and then is the Latitude of 49° . 04'. (by Observation) what Course hath she steer'd, and what's her Westing or Departure ?

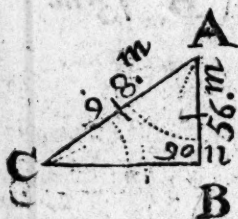
Prep. Lat. 50° . $00'$. — Lat. 49° . ; $04' = 56'$. or
Miles the 3^{d} . or Alteration of Latitude.

Projection Geometrically.

1. Draw A B the Meridian, and
set of 56 equal Parts for the α . Lat.
from A to B.

2. Because the Course is S^o. Westerly, raise the Perpendicular B C, toward the left Hand.

3. With



Plain-Sailing, Method 1.

44

3. With the Distance sail'd, 98 equal Parts between your Compasses, setting one Foot in A, the Place departed from; with the other cross the Perpendicular in C, the Place the Ship is in.

Lastly draw A C the Distance.

2. Mensuration.

Measure the Arch of the Angle of the Course $n, 8$, on the Chords, and you have $55^{\circ}.09'$. the Course South-Westerly; also apply B C, to your Scale of equal Parts, and it gives 80 Miles from the Departure or Westing.

3. Logarithmically.

1. As Dists. $\therefore R :: x$. Lat. S. C. Course.
 $\text{---} 98m. \text{---} S. 90^{\circ}. \text{---} 56m. \text{---} 34^{\circ} : 51'$. Which take from $90^{\circ}. 00'$. and you have $55^{\circ}. : 09'$. for the Course South-Westerly.

2. As $R ::$ Dists. $::$ S. C. $..$ Departure
 $\text{---} S. 90^{\circ}. \text{---} 98m. \text{---} S. 45^{\circ} : 09 \text{---} 80 \text{ Miles}$
 West.

4. Instrumentally, by G.S.

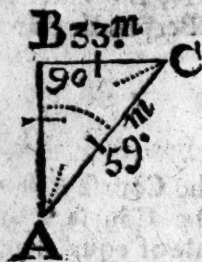
The Ext. $\left\{ \begin{smallmatrix} m \\ c \end{smallmatrix} \right\}$ Dists. 98 to x . Lat. 56m. $\left. \right\}$ on $\left\{ \begin{smallmatrix} Nrs. \\ Sines \end{smallmatrix} \right\}$
 reaches $\left\{ \begin{smallmatrix} m \\ c \end{smallmatrix} \right\}$ $R S. 90. \text{ to } S. C. C. 34^{\circ}. 51'$.
 The Ext. $\left\{ \begin{smallmatrix} m \\ c \end{smallmatrix} \right\}$ $R S. 90^{\circ}. S. C. 55^{\circ}. 09$ $\left. \right\}$ on $\left\{ \begin{smallmatrix} Sines \\ Numb. \end{smallmatrix} \right\}$
 reaches $\left\{ \begin{smallmatrix} m \\ c \end{smallmatrix} \right\}$ Dists 98m. to Depr. 80m.

Use. If you mistrust the Care of him that steers the Ship, that he has let her yaw or fall off, or that you have neglected the Variation, or met with thwart Currents, and are assured in your self of having made a good Estimate of the Distance run by the Log: Then with this Distance, and the true x . Latitude by Observation find the Course and Departure by this fourth Case or Plain-Sailing.

Case. 5. Given Distance run and Departure; required Course and x . Latitude.

Example. A Ship from the Latitude of $40^{\circ}. 10'$. North, sails between the North and East 59m, until her Departure or Easting, be 33m. I demand the Course she hath sail'd, and the Latitude she is in?

Geomet

*Geometrically.*

1. Draw the Meridian AB, and erect the Perpendicular BC, which make equal to the Departure 33 Miles = Parts.

2. With the Distance 59 Miles = Parts between your Compasses, and one Foot in C the Ship's Place; the other will cross the Meridian in A, the Place departed from.

Lastly, draw AC the Distance sailed. 2. The Course, and $\times$ Lat. AB is measured, as in the last Case; which you will find 34° . or N. E. by N. $15'$ Eastwardly, and the $\times$ Lat. 49 Miles.

3. Logarithmically.

1. As Dists. .. $R ::$ Departure S. Course.

———— 59m. ——— S. 90° . ——— 33m. ——— N. 34° . 00'. East

2. As $R ::$ Dists. $::$ S. C. C. .. $\times$ Lat.

———— S. 90 ——— 59 ——— S. 56° . 00'. ——— 49m. N. $15'$.

4. Instrumentally, by G. S.

The Ext. } $\begin{matrix} \text{from} \\ \text{reaches} \end{matrix}$ { Dist. 59 to Depr. 33m. } on { Nrs. }
 } $\begin{matrix} \text{from} \\ \text{reaches} \end{matrix}$ { R S. 90° . to S. C. 34° . } on { Sines. }

The Ext. } $\begin{matrix} \text{from} \\ \text{reaches} \end{matrix}$ { R S. 90° . S. C. S. 56° . } on { Sines. }
 } $\begin{matrix} \text{from} \\ \text{reaches} \end{matrix}$ { Dist. 59m. to $\times$ Lat. 49m. } on { Nrs. }

To the Latitude sail'd from ——— $40 : 10$ North

Add the $\times$ Latitude ——— $00 : 49$ North

Sum is the Latitude the Ship is in $40 : 49$ North

This Case is not of much Use.

Case. 6. Given the $\times$ Latitude and Departure, required the Course and Distance.

Example. Admit a Ship in the Latitude of 43° . 00'. North, is bound to a Port in the Latitude 43° . 52'. North, that lies 33 Miles to the Eastward of the first Port: I demand upon what Course, and how far she must sail to gain her intended Port.

Prep.

Prep. Lat. $43^{\circ} 00' - 43^{\circ} 52' = 52m.$ $\times$ Lat.

2. Geometrically.

1. Make AB on the Meridian equal to $52 =$ Parts, the $\times s$. Latitude.

2. Raise the Perpendicular BC, which make equal to $33 =$ Parts the Departure.

Lastly, Draw AC, then the Angle, BAC is the Course, and AC the Distance of the Ports, and are measured, as in the 4th Case foregoing.



3. Logarithmically.

1. As $\times$ Lat. $52m.$ $\therefore R$ $\therefore$ Depr. $33m.$ $\therefore$ Tang. Course, $N. 32^{\circ} 44'$ East
 2. As S. C. $S. 32^{\circ} 24'$ $\therefore$ Depr. $33m.$ $\therefore R$ $\therefore$ Dist. $61 \frac{1}{2}$ Miles

4. Instrumentally, by G. S.

The Ext. } $\begin{matrix} \text{on } \text{Nrs.} \\ \text{reaches } \end{matrix} \left\{ \begin{matrix} X. \text{ Lat. } 52m. \text{ to Depr. } 33m. \\ T. 45^{\circ} \text{ to Tang. C. } 32^{\circ} 24' \end{matrix} \right\}$
 The Ext. } $\begin{matrix} \text{on } \text{Sines} \\ \text{reaches } \end{matrix} \left\{ \begin{matrix} S. C. 32^{\circ} 24' \text{ to } R. S. 90^{\circ} \\ \text{Depr. } 33m. \text{ to Dist. } 61m. \end{matrix} \right\}$

Note, In the the first of these Extentions, if the Departure happens to be greater that the $\times s$. Latitude, you must count the Course increasing from Tangent 45° towards the left Hand, if the $\times s$. Latitude be greatelt as in this Case; count it from the left Hand towards 45° or the right. If the Departure and $\times s$. Latitude are equal Numbers, then your Course is always 45° from the Meridian. I might have given you other Varieties in Calculation, of these six common Cases of Plain-Sailing, as in making each Side the Radius of a Circle; but seeing it's of no great Use; and having done it in my rectangular Plain Trigonometry, I leave it to the Learner's Curiosity to make the Application here.

This sixth Case is of continual Use at Sea, when we have corrected our Courses from the Log, and found the $\times s$. Latitude and Departure made, by the Traverse Table, to find the Ship's Course and Distance made good.

Oblique

Oblique Plain Sailing should follow ; but seeing 'tis the most difficult and least useful in Navigation, I shall defer treating of it till after *Mercator's Sailing*.

Method 2. By the Traverse Tables.

Case. 1 *Given Course N. E. by N. Distance 107. Miles, required the Difference of Latitude and Departure ?*

BY Inspection in the T. Table, break the Distance into two Parts, 100 and 7.

Against (the Distance) 7 Miles, and under the Course (N. E. by N.) or 3 Points, you'll find 5.8 $\times$ Lat. and 3.9 Departure. Against the (Dist.) 100 Miles, and under 3 Points you have 83.1 Difference of Latitude, and 55.6 Depart. Then,

To $\times$ Lat. 5. — Depart. 3.9

Add $\times$ Lat. 83.1 — Depart. 55.6

The $\times$ Lat. = 88.9 — Depart. = 59.5

10

10

which was required.

Case. 2. *Given Course N. W. $\frac{1}{2}$ W. and difference of Lat. 70 Miles : To find the Distance and Departure.*

Take $\frac{1}{2}$ the $\times$ Lat. $\frac{70}{2} = 35$ m. Over N. W. viz. 4 $\frac{1}{2}$ Points, at the bottom of the Table, Titled Lat. find the $\times$ Lat. 35m. or nearest to it, which is 34.9. Against which on the left Hand, over Title Dep. you have 42.5. Departure. And over Title Dist. on the left Hand 55m. Distance. The double of each Dist. 110 Miles ; and Departure 85 Miles, as was required.

Case 3. *Given Course S. E. by S. and Departure 75m. Required Distance and $\times$ Lat.*

Under (N. E. by N.) 3 Points, and Title Dep. find the nearest N. to the Departure, which (in Parts) is 55.6. and 19.4. against which stands $\times$ Lat. 83.1. Dist. 100. and $\times$ Lat. 29.1. and Dist. 35. which being added together makes

makes the whole Distances 135m. and π . Lat. 112m.; W. W. required.

Case 4. Dist. 55m. and Dep. 42.5m. Given: Required Course, and π . Lat.

Right against Distance 55. and over Title Dep. find 42.5. and you have against it 34.9. for the π . Lat. and underneath at the Bottom, you find $4\frac{1}{2}$ Points, the Course, which if the Ship sail'd between the North and West, is N. W. $\frac{1}{2}$ W.

Case. 5. Given Distance 55m. and Difference of Latitude 35m. Required Course and Departure.

Right against Distance 55. and over Title Lat. (at the Bottom) find the π . Lat. 35. or nearest to it 34.9. Against which, on the left Hand, stands 42.5. or $42\frac{1}{2}$ Miles the Departure, and at the Bottom $4\frac{1}{2}$ Points: Which supposing the Ship sail'd South-Westerly, is S.W. $\frac{1}{2}$ W. the Course steer'd.

Case 6. Given $\left\{ \begin{array}{l} \pi. \text{ Lat. } 83, 1m. \end{array} \right\}$ reqd. $\left\{ \begin{array}{l} \text{Course} \\ \text{Dist.} \end{array} \right\}$

Find the corresponding Numbers 83, 1. and Dep. 55, 6. under Title π , Latitude and Departure (when the π . Lat. is greatest; but over Title Departure and Latitude, when the Departure is greatest) and at Top, (or the Bottom,) you have the Course 3 Points, which if in the N. E. quarter the Ship sail'd, is N. E. by N. And in either of the right or left Hand Columns, titled Dist. (or π . Long.) you have 100 Miles, the Distance sail'd, W. W. R.

Note, In the three first Cases of Plain-Sailing, if the Course be given in Degrees, make use of the Traverse-Table in Degrees; and proceed as before directed for Points of the Compass. Also in the three last Cases, if your Numbers, (as Distance and Departure, &c.) do not nearly agree together in the Traverse-Table of Points, then seek them in the Traverse-Table of Degrees, and proceed as there directed, and your Course will be found in Degrees: Observing always to reckon your Points or Degrees of the Course from the North and South Points, towards the East and West, according to the Quarter of the Compass the Ship hath sail'd in.

Method. 3. By Natural Arithmetick.

And (the so called) given Numbers, which are nothing else but the Natural Sines, Tangents, &c. to every half Point and quarter Point of the Compass, or Course steer'd; and may readily be collected from the afore-said Traverse Tables, *Viz.*

By taking the *x.* Latitudes and Departures, answering to the Points and Quarters of the Compass, against the Distance 100 Miles, if these (given or) natural Numbers be committed to Memory, we may give a Solution to Plain Sailing, by common Arithmetick, without Books or Instruments. See the three first Columns of the Table, N^o. 17. $\times$ The 1. represents the Points and Quarters, the former in literal, and the latter in numerical Figures, in their natural Order, against which stands the natural Sines and natural Tangents to the said Points, &c.

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Example.

What's the natural Sine and its Complement of a S. W. half W. Course being 4 Points 2 Quarters from the Meridian, and its Complement 3 Points 2 Quarters? I find IV. and $\frac{1}{2}$ in the first Column, against which stands N. Sine 773. (and N. Tangent 1218.) and against III. and 1, 2, downwards, N. Sine 634. (N. Tang. 826.) the Complement of the Course; which indeed is obvious to any, without any Example. Proceed we now to

Case 1. Given Course, N. E. by N.

Dist. 107m. Requir'd *x.* Lat. and Departure.

By the Rule of Three.

P. P.

1. As R. VIII. Dist. :: S. C. III. Depr

N. m N.S. m

As 1000 :: 107 :: 355 .. 59. and $\frac{32}{1000}$

P.

P.

2. As R. VIII. Dist. :: S. C. C. V. x. Lat.

N. Sine m N.S. m

— S. 1000 :: 107 :: 831 .. 88, $\frac{217}{1000}$

Case 2.

Case 2. Given, Course N. W. half W. $\times$. Lat. 70m.
To find the Distance, Run, and Departure.

As S. C. C. .. $\times$. Lat. $\therefore$ R. .. Distance,
N. S. m. N. S. m
— 634 — 70 — 1000 — 110, 260.

As S. C. C. .. $\times$. Lat. $\therefore$ S. C. .. Depart.
m m
— 634 — 70 $\therefore$ 773 — 85, 220.

Case 3. Course, S. E. by S. Departure 75m. Given:
To find the Dist. and $\times$. Lat.

As S. C. .. Departure $\therefore$ R. .. Distance
— 555 — 75 — 1000 — 135 Miles.

As S. C. .. Depr. $\therefore$ S. C. C. .. $\times$. Lat.
m
— 555 — 755 — 831 — 112, 55 Miles.

Case 4. Dist. 135m. and $\times$. Lat. 112. 55m.
Given. Requir'd Course, and Departure,

As Dist. .. R. $\therefore$ $\times$. Lat. .. S. C. C.
— 135m. .. 1000 — 112.5. .. 833. the nearest
to which in the Table (or by your Memory) is 831,
against which stands 5 Points, whose Comp. 3 Points is
the Course, S. W. by S. if the Ship sails South-
westerly

As R. .. Dist. $\therefore$ S. C. C. Departure
— 1000 — 135 555 — 74, 925 Miles.

Case 5. Given Distance, 135m. and Departure, 74, 9m.
Requir'd Course, and $\times$. Lat.

As Distance .. R. $\therefore$ Departure .. S. C.
— 135 .. 1000 — 74, 9 — 554 $\frac{1}{2}$. the nearest
N°. to which is 555, or 3 Points; or S. W. by S.

As R. .. Dist. $\therefore$ S. C. C. .. $\times$. Lat.
— 1000 — 135 — 831 — 112, 185 Miles.

Case 6.

Case 6. Given $\times$. Lat. $11^{\circ}2'$. and Depart. 75^m .
Requir'd Course and Distance.

As $\times$. Lat. .. R :: Depart. Tang. Course
— $112,2$.. 1000 — $75^m,669$, the nearest N° is
N. Tang. 668 ; against which stands 3 Points; so the
Course is S. W. by S. as before.

As S.C. Depart. :: R .. Dist.
— 555 — 75^m — 1000 — 135^m .

Method 4. Plain-Sailing.

See the second Table annex'd to the Table for finding
the Miles answering a Degree of Longitude in any
Latitude, ($N^{\circ} 20.$)

Rule. As the tabular Distance is to the true Distance;
so is the tabular Departure to the true Departure re-
quir'd.

Again,

As the tabular Distance is to the true Distance, so
is the Difference of Latitude upon all Rhumbs, (60
Miles) to the true $\times$. Lat. requir'd.

The Table is thus calculated for every Point, and
Quarter-point of the Mar. Compass, the $\times$. Latitude be-
ing 60 (or 1 Degree) by Case 2d. of P. S. laying; As
S.C.C. of any Point, or Quarter-point given, is to the $\times$.
Lat. 1° or 60^m , so is Radius 90° to the tabular Distance
required.

Again,

As S.C.C. of any Rhumb, or Point, is to the $\times$. Lat. on all
Rhumbs 60^m , so is the S. of the said Rhumb, to the ta-
bular Departure required.

Case 1. Course N. E. by N. } Demd. } $\times$. Lat.
Dist. 107^m } } Depr.

As Tab. Dist. .. true Dist. :: Tab. Departure, ..
true Departure.

— $72,2^m$ — 107^m — $40,1$ — $59,3^m$.
As Tab. Dist. .. true Dist. :: $\times$. Lat. on all R.
.. true $\times$. Lat.

— $72,2^m$ — 107^m — 60^m — $88,9^m$.

Case

Plain-Sailing, Method 4.

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Case 2. Course N. W. $\frac{1}{2}$ W. } Reqd. } Dist.
 α . Lat. 70m. } Depart.

As α . Lat. Given :: Tab. Dist. Tr. Dist.
 — 60m. — 70m. — 94, 6m. — 110, 3m.

As α . Lat. .. α . Lat. given :: Ta. Dep. Tr. Dep.
 — 60m. — 70m. — 73, 2m. — 85, 3m.

Case 3. Course S. E. by S. } D. D. } Distance
 Departure 75m. } Demd. } α . Latit.

As Ta. Dep. .. Tr. Dep. :: Tab. Dist. .. Tr. Dist.
 — 40, 1 — 75m. — 72, 2 — 135m.

As Ta. Dep. .. Tr. Dep. :: Ta. α . Lat. Tr. α . Lat.
 — 40, 1 — 75m. — 60 — 122m.

Case 4th, 5th and 6th, are solved by the 47th of the 1st of Euclid's Elements, and the Number 86, to find the Course thus ;

Case 4. } Dist. between S. and W. 135m.
 } and α . Lat. 112m. given ; to find the
 } Departure and Course.

Rule. The Square Root of the Difference of the Squares of the Distance, and α 's Latitude is equal to the Departure.

Solut. $135 \times 135 = 18225$ the Square of the Distance.
 And $112 \times 112 = 12544$, the Square of the α . Lat.

Then $18225 - 12544 = 5681$, the α . Whose

$\sqrt{5681} (= 75$ the Departure required.

Now to find the Course in this, and the 5th. and 6th. Case, observe this Rule:

As the Sum of the Dist. more $\frac{1}{2}$ the greater Side, be it either the α . Latitude, or Departure, is to the lesser Side, either α . Lat. or Departure ; So is 86 (always) to the Angle of the Course required.

Operation.

Dist. + $\frac{1}{2}$ α . Lat. i. e. $135 + 56 = 191$ Z.

As Z 191 .. 75 :: 86 .. $33^{\circ} : 46'$ $\angle$ of the Course, that is, S. W. by S.

E

Note,

Note. To bring out the odd Minutes, multiply the Remainder of the Division by 60 (the Minutes in a Degree) and divide the Product by the same Divisor, it exhibits the Minutes. Or annex two Cyphers to the said Remainder, and divide as before, the Quote multiply by 60, cutting off two Figures from the Right-hand, the Residue shews the Minutes, as before.

1. Observe the same Rule and Method for finding the Course in the two following Cases.

2. If the α . Lat. be greater than the Departure (as in the last Case) the Operation finds the Sine of the Course: But if the Departure be greater than the α . Lat. it finds the Complement of the Course, which subtracted from 90, gives the Angle of the Course.

Note. If the Learner cannot extract the Square Root, (I refer him to a Table of Squares, See (Number 8.) for his Ease, whereby may be found the Squares, or Square Root of any Number (not exceeding 330, which is sufficient) by Inspection. As for Instance; What's the Square of 135? Look under N. 135. against which on the Right-hand, stands 18225, its Square required.

I would know the Square Root of 5625. Look under Title *Squ.* for the Number given, 5625 (or nearest to it) against which, on the Left hand, stands 75, the Square Root sought.

Case 5. $\left\{ \begin{array}{l} \text{Distance S. Wly. 135 m. Dep. 75 m.} \\ \text{given; required Course, and } \alpha \text{. Lat.} \end{array} \right.$

Rule. The Square Root of the Difference of the Squares, of the Distance and Departure is equal to the Difference of Latitude required.

Operation.

$$135 \times 135 = 18225, \text{ square Distance.}$$

$$75 \times 75 = 5625, \text{ square Departure.}$$

m.

There $\sqrt{12600} (= 112 \alpha \text{. Lat.})$

As $Z \text{ Dist. } + \frac{1}{2} \times \text{Lat.} \therefore \text{Depart.} \therefore \text{given No. } \sqrt{\text{Cour.}}$

$$\text{————— } 191 \text{ ————— } 75 \text{ ————— } 86 \text{ ————— } 33^\circ : 46.$$

i. e. Course S. W. by S.

Case.

Case 6. $\left\{ \begin{array}{l} \text{N. Lat. } 112\text{m. Departure, } 75 \text{ W.} \end{array} \right.$

Given; Course and Distance required.

Rule. The Square Root of the Sum of the Squares, of the Difference of Latitude, and Departure, is the Distance sought.

Operations.

$$112 \times 112 = 12544 \text{ square N. Lat.}$$

$$75 \times 75 = 5625 \text{ square Departure}$$

There Z. $\sqrt{18169} (= 134,8\text{m. Dist. or near } 135 \text{ Miles.} \dots)$

As Z Dist. $\frac{1}{2}$ N. Lat. $\therefore$ Depr. $\therefore$ Gn. No. $\checkmark$ Course
 $\frac{191}{75} \frac{86}{33^\circ : 46^\circ}$

The Course is S. W. by S. W. W. R.

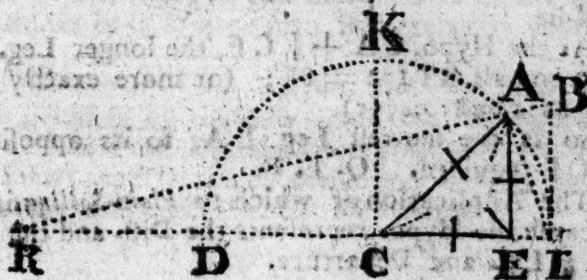
If the Departure is greatest, the Answer will be the S. Comp. Course.

I shall now shew how the given Number 86 was found out, by Snellius, (altho' omitted by all our Authors of Navigation, who have used it in Operation.)

Theorem.

As the Sum of the Hypothenuse, and $\frac{1}{2}$ the greater Leg, (be it Base or Perpendicular) is to the lesser Leg;

So is 86, a constant Number, to the Angle opposite to the said lesser Leg, (be it either Base or Perpendicular.)



Construction.

In the Scheme above, let the right-angle Triangle propos'd be CEA ; then with the Radius CA ($=$ Hypothenuse) describe the Semi-circle IKD , and producing the Diameter towards R , make $DR =$ Radius, CA or CD ; draw also the Tangent Line IB , and the Line RA produced to meet the Tangent IB in B ; then shall the Tangent IB be equal (or sufficiently near) to the length of the Chord Line IA , which is equal to the Angle ACE required; and RI is the Triple of the Radius CI , or Hypothenuse $A.C$.

Demonstration.

Let the Tangent Line IB be equal to the Cord Line IA ; AE being parallel to IB , the Triangles $RI B$ and REA are similar, by reason of the parallel Line AE to IB ; therefore proportional by the 6th of the 4th of *Euclid*, And 'twill be

$$\text{As } RE \dots EA :: RI \dots IB. \text{ And}$$

$$\text{As } RE \dots EA :: RI \dots IA (= IB.)$$

The Cord of the Angle ACE , which must be accounted an Arch of a Circle, whose Circumference is $= 360^\circ$, its half $= DI$. Now let the proportion of the Diameter of a Circle to its Circumference be as 7 to 22; Or as 113 to 355. — Then; As 113 .. 355 :: 363 .. 114, 5915, the Diameter DI , in such Parts whereof the whole Circumference is 360° : Now, the half of 114, 5915, is $= 57,2957 =$ Radius IC , which tripled is $= 171,8871$; equal to RI by Construction; but for common Use we use 172, not minding the Fraction; and $RD = DC = CA =$ Hypothenuse; and C is the longest Leg. And therefore it will be, As $RE =$ twice the Hypothenuse, $CA + CE$, the longer Leg, is to $RI = 172 =$ thrice the Radius. So is EA the shortest Leg. to $IB = IA =$ Angle ACE required. Or more briefly, by taking half the two first Terms, it will be,

As the Hypo. $CA + \frac{1}{2} CE$, the longer Leg.

Is to half RI $172 = 86$; (or more exactly half RI $171,8871 = 85.94355$)

So is the shortest Leg EA , to its opposite Angle ACE required. Q. E. D.

The Application of which to *Plain-Sailing* is obvious, because the Hypo. represents the Dist. and the two Legs the $\angle$ Lat. and Departure.

Plain.

Plain-Sailing. Meth. 5.

The Solution of Plain-Sailing by Natural Arithmetick, by the Pen only.

First, You must find whether the Difference of Latitude or Departure be the longest Side in the Triangle, and that is easily known thus; 1. If the Course be less than four Points from the North or South, the $\times$. Latitude is greater than the Departure, 2. If the Course be more than four Points from the North or South, the $\times$. Lat. is less than the Departure. 3. If the Course be just four Points, the $\times$. Lat. and Departure are both equal: Then, if the $\times$. Lat. be the lesser Side, it must be assumed 1,0000. If the Departure be less, it must contain 1,0000. Then the Rule is,

1. Always divide 172 (the double of 86, before found with a competent Number of Cyphers annexed, by the Degrees and decimal Parts of a Degree contained in the Angle opposite to the lesser Side.

2. From the Square of this Quotient, you must always subtract 3, and out of the Remainder extract the Square Root.

3. Subtract this Square Root from the double of the Quote, $\frac{1}{2}$ of this Remainder shall be the Distance assumed.

4. Subtract the Double of the assum'd Distance from the said Quote, the Remainder shall be the assumed Difference of Latitude, or Departure, according to the Scale, whereby the lesser Side contained 1,0000.

And thus you'll have a Triangle whose Sides shall be similar and proportional to the Sides of the *Plain-Sailing* Question proposed; which Sides requir'd may be found by the *Rule of Three*.

Lastly, in this Method you must reduce all the sexagenary Minutes in a Degree into Decimals, by this Proportion,

As 60' .. 10000 :: 15 .. 2500, the Decimal of 15 Minutes; and so by the rest. And by this Proportion was the Table of Decimals and Minutes calculated, which shews the Decimals contained in any Number of Minutes; and contrary, by Inspection.

NAVIGATION.

C. 1. Given Course N. E. by N. Distance 107m. Re-
quir'd $\propto$ Lat. and Departure.

By the first Observation, the Course being less than
four Points, $\propto$ Lat. is greater than the Departure ;
therefore the Departure must be assumed 1,000. And
the Angle given is,

$33^{\circ} : 45''$. Or in Decimals $33^{\circ}, 75'$.

Operation.

$33,75) 172,00000 (5,096$ Quote.

2

Double Quote = 10.192

$5,096 \times 5,096 = 25,969,216$ Quote squar'd ; less 3 is
 $= 22,969,216, \sqrt{2} = 4,792$ Sq. Root.
Then from the double Quote 10.192, subtract the
Square Root

4,792

Remains

5,400

$\frac{1}{3}$ of the Remainder is the ass. Dist.

1,800

The Dist. doubled is

3,600

Which subtracted from the Quote,

5,099

The Remainder is the assum'd $\propto$ Lat. =

1,496

Then by the Rule of Three,

As supposed Dist. .. true Dist. :: sup. Dep. true Dep.

1,8 — 107m. — 1,500 — 59. +m.

As sup. Dist. .. true Dist. :: sup. $\propto$ Lat. true $\propto$ Lat.

1,8 — 107m. — 1,5 — 89m. +.

Case 2. Course N. W. half W. $\propto$ Lat. 70m. given ;
Distance and Departure required.

The Angle of the Course is $39^{\circ} : 22'$; or in Decimals,
39.3667. Here the $\propto$ Lat. is the lesser Side, and must be
1,000.

39,3667) 172,000000 (4,39 Quote:
 $\begin{array}{r} 2 \\ \hline \end{array}$
 Double Quote $\begin{array}{r} 8,78 \\ \hline \end{array}$
 Quote Squar'd less, 3 is $\begin{array}{r} 16,2721 \\ \hline \end{array}$
 Whose Square Root is $\begin{array}{r} 4,03 \\ \hline \end{array}$
 Subtract from double Quote $\begin{array}{r} 8,78 \\ \hline \end{array}$
 Remainder is $\begin{array}{r} 4,75 \\ \hline \end{array}$

$\frac{2}{3}$ of the Remainder is the Dist. $\begin{array}{r} 1,583 \\ \hline \end{array}$

The Dist. double is $\begin{array}{r} 3,166 \\ \hline \end{array}$
 Which subtract from Quote $\begin{array}{r} 4,39 \\ \hline \end{array}$

Remainder is the assumed Depart, $\begin{array}{r} 1,224 \\ \hline \end{array}$

Then by Proportion say,

As sup. $\times$. Lat. true $\times$. Lat. $\therefore$ sup. Dist. true Dist.
 $\begin{array}{r} 1,000 \quad 70 \quad 1,583 \quad 111,9m. \\ \hline \end{array}$
 As sup. $\times$. Lat. .. true $\times$. Lat. $\therefore$ sup. Dep. true Dep.
 $\begin{array}{r} 1,000 \quad 70 \quad 1,224 \quad 85,6m. \\ \hline \end{array}$

Case 3. Course S. E. by S. Depart. 75m. given; to find Dist. and Diff. of Lat.

The Angle of Course is $33,75$ as the first Case. Consequently the Departure is the lesser Side, and must contain 1,000.

Therefore by the first Case, $\frac{122,00}{33,75}$
 Quote = 5,096: Which doubled, is 10,192

and the Square thereof 25,969216; made less by 3, is = 22,969216; whose Square Root is 4,792, as before.

Then from Quote doubled $\begin{array}{r} 10,192 \\ \hline \end{array}$
 Subtract the Square Root $\begin{array}{r} 4,792 \\ \hline \end{array}$

Remains $\begin{array}{r} 5,400 \\ \hline \end{array}$

$\frac{1}{3}$ of the Remainder is the Dist. $\begin{array}{r} 1,800 \\ \hline \end{array}$

The Distance doubled is, $\begin{array}{r} 3,600 \\ \hline \end{array}$
 Which subtracted from Quote $\begin{array}{r} 5,096 \\ \hline \end{array}$

The Remainder is the assumed α . Lat. 1.496

Then say,

As sup. Dep. .. true Dep. $\therefore$ sup. Dist. true Dist.
 ——— 1,000 ——— 75 ——— 1,8 ——— 135m.

As sup. Dep. .. tr. Dep. $\therefore$ sup. α . Lat. tr. α . Lat.
 ——— 1,000 ——— 75 ——— 1,496 ——— 112,2m.

The 4th, 5th, and 6th Cases are wrought by the Square Root, and Number 86; as in Method the 4th foregoing, which to avoid Prolixity, I omit, and proceed to

Method 6th. Plain-Sailing.

In this Method, (which is the same as in *Wilson's Navigation* new Modell'd, Page 161.) there must first be a Number found, called the Natural Radius, which may produce the same Answer in Natural Arithmetick, that the Radius, or Sine of 90° produces in a Sinical Proportion, or by Logarithmic Sines: And this Natural Radius the aforesaid Author directs us thus to find by this

Axiom

Take the Angle whose opposite side is either given or sought, and divide four times the Square of its Complement to 90° by 300. added to 3 times the said Complement, and then the Quotient added to the said Angle is the Natural Radius required.

And this Rule is universally true in all Angles, from 0 , to 90° .

But because in Angles under 45° , the Complements are above 45° ; and the Squares amount to greater Numbers than the Squares of the Complements of the Angles above 45° . Therefore, to render the Work yet more easy, in finding the Natural Radius for all Angles under 45° the Rule, or *Axiom* 2. is; Divide 3 times the Square of the Angle (whose opposite Side is given or sought) by 1000, the Quotient added to 57,3, the Sum is the Natural Radius requir'd.

Then Rule 1. is, an Angle and Side given, to find another Side.

Say,

Say, As Natural Radius is to the Distance; So is the Angle (of the Course or its Complement) by which the Natural Radius was found, to its opposite Side (the Departure, or $\times$ Lat.)

Thus, when the Course and Dist. is given. But if the Course and $\times$ Lat. or Course and Departure be given; As the Angle (of the Course, or Comp.) to its opposite Side (the Departure, or $\times$ Lat.) So is Natural Radius, to the Distance required.

Note, 57,3 is the Semi-diameter, or Radius of a Circle, whose Circumference is 360.

Case 1. Given Course N. E by N. Dist. 107 Miles; required the $\times$ Latitude and Departure?

Note. 'Tis best to find the lesser Side required first, because Natural Radius is more easily found by Axiom 2.

The Course is the lesser Angle 33,75, whose Square viz. $33,75 \times 33,75 = 1139,0625$

Multiplied by 3

1000) 3,417, (1875

57,3 Added

60,717 is the Natural Radius;

or more brief, 60,7, which is exact enough: Then say,

As Nat. Rad. .. Dist. :: S. C. .. Departure,

60,7 — 107m — 33,75 — 59,4 m, reqd.

Then find the $\times$ Latitude by Case the 5th. Meth. 4. Thus,

The Distance squared is 11449,

Departure squared is 3481.

Their Difference is 7968 Miles,

Whose Square Root = 89m. the $\times$ Latitude required.

Case 2. Course N. W. half W. $\times$ Latitude 70m. given, to find the Distance and Departure?

Here the Side given is also opposite to the lesser Angle; therefore by Axi. 2. Co. Course is 39°, 36'

The Square of 39,36 is 1549,2

Multiply by 3

Divide

Divide by 1000) 4,6 (47,6
To which Add 57,3
—

The Natural Radius = 61,9 or 62

As S. C. ... Lat. ∴ Nat. Rad. ... Dist.
— 39,36 — 70m. — 62 — 110,2m.

Then for the Departure by the square Root, and by Method 4. Case 4. The Square of the Distance is 1211, 44, and the Square of the $\propto$ Latitude is 4900, their Difference is 7244, whose square Root is 85 Miles, the Departure required.

Case 3. Course S. E. by S, Departure 75 Miles given; required Distance and $\propto$ Lat.

Here the Departure is the shortest Side, and the Angle of the Course is 33,75; therefore, the natural Radius is the same as in the first Case of this Method, viz, 60,7. Then the Proportion is,

As S. C. .. Dept. ∴ Nat. Rad. .. Dist.
— 33,75° — 75m. — 60,7° — 135m.

Then by the square Root find the $\propto$ Latitude as in the Case of this Method.

The Distance squar'd is — 18225
The Departure squar'd is — 5625

Their Difference is 12600

$\sqrt{12600}$ (= 112 Miles the Difference of Latitude required.

Sometimes the Angle of the Course is given in Degrees, often in Use in our Ships of War; therefore I shall give an Example more to the first Case, and work it by the first Axiom. Ex. Course N°. 56° Et. Dist. 90m. given; Difference, Latitude and Departure required.

Here the Departure required is opposite to the bigger Angle;

Therefore by Axiom 1. $90^\circ 56^\circ = 34^\circ$ Comp.
34° squar'd is = 1156

Multiply by 4
Dividend 4624

Plain Sailing. Method 6.

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$34^{\circ} \times 3 + 300 = 402$ Divisor
 And $102) 4624 (= 11,5$
 To which add 56 the bigger $\angle$
 Sum is the Natural Radius 67.5 Then say,
 As Nat. Rad .. Dist. :: S. C. .. Depr.
 $\frac{67.5}{90m.} = \frac{50^{\circ}}{74.6m.} +$
 The $\angle$ Latitude is found as before in Case 1. of this
 Method, which is 50 Miles.

Method 7. Plain Sailing.

By the Sinical Quadrant, Page 60 following

This Geometrical and Trigonometrical Instrument, exhibits the various Traiangles (or Cases) in Plain Sailing, Traverse and Mercator's Sailing, (projected; and measured to your Hand at the first viewing of it) and is very exact and easy in Operation.

Construction. It is composed of concentrick Arches, (or rather quarters of Circles) and of three Sorts of right Lines, viz.

1. Those drawn parallel to the Line A P, represent the Sines and Meridians, and are parallel to the North and South, upon which we count the Miles or Leagues of $\angle$ Lat.

2. Those drawn parallel to the Line A C represent the Sines, Complements and Parallels, and are Parallels to the East and West, upon which we count the Miles or Leagues of Departure from the Meridian. And,

3. Those drawn from the Center of the Quadrant A, to the Limb, represent the Rhumbs or Points of your Compass, or several Courses steerd, and it is upon them that we count the Distance, or Miles, or Leagues sailed; which Miles or Leagues are distinguished or marked by the several Arches or Quarters of Circles.

Lastly, You must have a Silk Thread through the Center A, fastened by a Knot underneath, and then is this Quadrant fit for Use, which we come now to shew.

Case

Case 1. *Course S. W. by S. Distance 45 Leagues given to find the α . Latitude and Departure.*

Count 45 1. upon the third Rhumb (or Point from the North) to wit, upon the Arches, and from that Point (where you are to prick a Pin.) follow that Line to the Meridian A P, and you will have on the said Meridian 37 1. for the α . Latitude; and running down your Eye perpendicular to the Parallel A C. you have 25 Leagues for the Departure, which was requir'd.

Case 2. *Course S. W. by S. α . Lat. 36 Leagues; required Distance and Departure?*

Practice. Count upon the Meridian A P 36, and observe where it cuts the third Rhumb (pricking down your Pin there) the Arch intersecting this Point, trac'd (or followed) to the Meridian A P, gives 43 Leagues for the Distance; and again, tracing down the Meridian Line from the said Pin or Point, to the Parallel A C, you have nearly 24 Leagues for the Departure required.

Case 3. *Course N. E. by N. Departure 26 Leagues given; to find the Distance and α . Latitude?*

Practice. Count on the Parallel A C. 26. and tracing up that Meridian Line, till it cut the third Rhumb-Line, pricking your Pin down there, trace the intersected Arch to the Meridian A P, or Parallel A C, and it gives 47 Leagues the Distance requir'd; and tracing along the parallel Line, that intersects the Point or Pin, to the Meridian A B, you will find 39 Leagues the α . Latitude required.

Case 4. *Distance between the South West 55 Leagues, and α . Latitude 39 Leagues given, to find the Course and Departure?*

Practice. Counting on the Arches from the Center A 55, and on the Meridian A P 39. Observe the Intersection of the Arch with the parallel Line from A P, (pricking down the Pin there,) which Point of Intersection falls upon the fourth Rhumb; therefore the Course is S. W. and the α . Latitude given, viz. 39 Leagues.

Case 5. *Distance between the North and East 29 Leagues, and Departure 24 Leagues given; to find the Course and α . Latitude?*

Practice. Counting as before from A on the Arches 29, and upon the Parallel A C 24. Trace the Meridian Line, and 'twill intersect the Arch 29, on the fifth Rhumb; therefore the Course is N. E. by E. And running along the Parallel from the foresaid Point to the Meridian A P, 'twill cut it in 16 Leagues, the π . Latitude required.

Case 6. *Diff. Lat. 39 Leagues, and Departure 16 Leagues, (between the S. and W.) demand Course and Distance?*

Practice. Count upon the Meridian A P 39, and on the Parallel and Meridian from those Points intersecting each other, (pricking down your Pin in that Point) which you will find in the second Rhumb-Line; so that the Course is S. S. W. and also tracing the Arch intersecting the foresaid Point to the Meridian Line A P or Parallel A C, and it gives 42 Leagues for the Distance required.

Thus have I gone through all the various modern Methods of Plain-Sailing; viz.

1. By the Plain Chart.
2. Geometrical.
3. Logarithmetical.
4. Instrumental, by Gunter's Scale.
5. By the Traverse Tables.
6. By natural Arithmetick, by given Numbers, or natural Sines of Rhumbs and Quarters.
7. By another Table of given Numbers, and the square Root and Number 86, Arithmetically.
8. By Natural Arithmetick, and a similar Triangle, whose lesser Leg must be assumed 1,000.
9. By finding a Radius to work by natural Numbers.
10. By the Sinical Quadrant.

I pass on now to *Plain-Sailing Traverse*.

C H A P. III.

Plain-Sailing Traverse.

A Compound Course or Traverse is, when a Ship, upon the shifting of Wind, or other Accidents or Occasions, sails upon several Courses in 24 Hours.

Reducing or resolving a Traverse (after Lee-way and Variation hath been allow'd for, as shall be shew'd when we come to treat of Working a Day's Log, and keeping a Sea-Journal) is to reduce the several Courses by the Compass, and Distance found by the Log, into one Course and Distance.

Example i. Yesterday at eight in the Evening, the Lizard-Point bore off us N. W. by N. Distance about 6 Leagues, and we have sailed till this Day at Noon as by the Log-Board, viz. the Star-board Tack aboard, the Winds from W. to W. N. W. N. W. W. S. W. and S. W. Courses steered are S. S. W. 15m. S. W. 12m. W. S. W. 14m. S. 9m. S. S. E. 12m. I demand the α . Latitude and Departure, the Latitude in, and the direct Course and Distance from the Lizard?

Construction.

1. By Prob. 2. of Geometrical Prob.) with a Chord of 60° describe a Circle and quarter it with the two Diameters N. S. (produc'd) and W. E. for the North, South, East and West Points.

Operation. You may find the several α . Latitudes and Departures, to the several Courses and Distances by the first Case of *Plain-Sailing*, by any (or all) the foregoing Methods; but the most expeditious and easy, (practised at Sea) is by the *Traverse Table, Method 2. Plain-Sailing*. Thus; as in the first Case thereof, making a Table of seven Columns as here under; then collecting the several α . Latitudes and Departures to each Course and Distance, place them in the *Traverse Table*, observing this Rule here under the Table:

Course	D	P.	N ^o .	S ^o .	East	West
S.S.W.	15	2		13. 8		5. 7
S. W.	12	4		8. 3		8. 3
W.S.W.	14	6		5. 3		12. 9
S ^o .	9	0		9. 0		
S. S. E.	12	2		11. 1	4. 6	

α . Lat. S^o. 47. 7 | 4. 6 | 27. 1 W.
 ----- Sub. 4. 6 E.

Departure 12. 5 W.

Lat. Lizard 49° 56' N.

α . Lat. 00 : 48 S | 7. Sub.

Lat. come into 49 : 08 N.

Rule. When the Course is N^o. Easterly, place the α . Latitude in the North Column and Departure in the East Column; but when the Course is S^o. Westerly, place the α . Latitude in the South, and Departure in the West Column.

The adding { North } Column { South } Columns
 up { West } and { East } Columns
 Their Difference is the { Diff. Lat. } of the same
 Name with the greater. { Departure }
 See the Work above.

Plain-Sailing, Traverse.

65

For the Course and Dist. by Case 6. Plain-Sailing, Method 1.

As x . Lat. ... R Depr. Tang. Course.
 — 48m. — 90° — 23m. S° 25. 29'. West.
 As S. C. ... Depr. ... R Dist.
 — S. 25°. 29'. — 23 — S. 90°. — 53 Miles.

Or, more Expeditious by G. S.

The Ext. } x . Lat. 48m. to Depr. 23m. } on { N. x .
 reaches } { T. 45° to T. C. 25°. 29'. } { Ints.
 The Ext } S . C. 25°. 19'. to R . S. 90°. } on { Sines
 reaches } { Depr. 23m. to Dist. 53m. } { N.

Example 2. Yesterday Noon we were in the Latitude of 49°. 08' N. and till this Day Noon we have sailed as by the Log-Board with our Star-board, Tacks aboard, viz. S. by W. 19m. S. W. by S. 10m. S. W. by W. 6. W. S. W. half W. 8m. W. by N. 7m. N. W. 2m. Star-board Tack, aboard, S°. 5m. S.S.W. 6m. S. W. 2m. W. S. W. 3m. smooth Water and a small Gale. Winds, at S. E. by E. S. E. by S. S. by E. S. half W. S. W. by S. W. S. W. West. W. N. W. N. W. I demand the x . Latitude and Departure, direct Course and Distance made good, with the Latitude the Ship is in?

Traverse Table.

Course	x. Lat.		Dep.	
	D.	P.	S.	E. W.
S. b. W.	19	1	18.6	3.7
S. W. b. S.	10	3	8.3	5.6
S. W. b. W.	6	5	3.3	5.0
W. S. W $\frac{1}{2}$ W.	8	6 $\frac{1}{2}$	1.4 3.8	7.1
W. b. N	7	7	1.4	6.9
N. W.	2	4		1.4
S.	5	0	5.0	
S S. W.	6	2	5.5	2.3
S. W.	2	4	1.4	1.4
W. S. W.	3	6	1.1	2.8

2.8 47.0 Dep. 36.2 W.

I
F.

2.8
—
—

x La-
 x La-

α . Latitude 44.2° S.

Latitude from $49 : 08$ N.

α . Latitude $00 : 44$ S.

Latitude in $48 : 24$ N.

Having finished your Traverse as directed in the last Example, you may readily find the Course and Distance by *Gunter's Scale*, as there is shewn, *viz.*

The Ext. } α . Lat. 44^m , to Dep. 36^m . } $\frac{1}{5}$ { Nrs.
reaches } $\frac{1}{5}$ { T. 45° . to T. C. S. $39^{\circ} 10'$. W. } $\frac{1}{5}$ { Trs.
The Ext. } S. C. $39^{\circ} 10'$. to S. 90° } $\frac{1}{5}$ { Sines.
reaches } Dep. 36 to Dist. 57^m . } $\frac{1}{5}$ { Nrs.

Note. If the Tenth Parts of the α . Latitude and Departure be less than 5, we throw them away; if more than 5, make the Miles one more.

I shall give a Solution to one more Traverse, and that the most general and useful as may be; which being well understood, will be sufficient for the Learner's Purpose.

Being Yesterday Noon in Latitude of $48^{\circ} 24'$ N. and am bound to a Port in the Latitude $40^{\circ} 54'$ N. which is 510 Miles to the Westward of my Ship; but finding the Wind variable, I plie to Windward upon these several Courses, *viz.* S. W. by W. 25 Leagues, W. by S. half W. 30 Leagues, N. W. by W. 20 Leagues, West 35 Leagues, N. by W. 40 Leagues, S. W. by S. 50 Leagues, S. S. E. 25 Leagues, S. by W. 60 Leagues. I demand the α . Latitude and Departure, Course and Distance and Latitude the Ship is in, with the Course and Distance from the Ship to her Port at first Setting out, and at the End of her Sailing the above-said Courses?

From Lat. Depart. $48^{\circ} 24'$
Subt. the Lat. of the Port $40 : 54$

5.2	2.2	2.0	W. 2.2
4.1	1.8	4.2	W. 2
2.2	1.1	2.2	W. 2.2

$\propto$. Lat. 90.0 Depr. 139.6

Lat. from _____ 48°. 24. N

$\propto$. Lat. 90 Leagues, or _____ 4 : 30 S.

Latitude the Ship is in _____ 43 : 54 N.

As $\propto$. Lat. .. Departure :: $\propto$.. Tang. Course
 _____ 90m. _____ 140m. _____ T. 45 _____ S. 57°. 30'. W.

As S. C. $\propto$:: Depr. .. Dist.
 _____ S. 57°. 30'. _____ S. 90m. _____ 140m. _____ 165 Lea.

So that the Ship's Course made good is S°. 57°. 30'.
 W. her Distance run 165 Leagues, and she is arrived into
 the Latitude of 43°. 54. N°.

3. To find the Course (Bearing and Distance from
 the Ship to her intended Port. It's plain that the Port
 is to the South-westward of the Ship, because she hath
 not run her Southing 150 Leagues, and Westing 170
 Leagues down; Therefore

From $\propto$. Latitude _____ 150 Leagues

Take $\propto$. Latitude made _____ 90 Leagues

Remains $\propto$. Latitude to the Port _____ 60 Leagues

From Departure _____ 170 Leagues

Take Departure made _____ 140 Leagues

Remains the Departure to the Port 30 Leagues

Therefore by Case 6. of *Plain-Sailing*:

As $\propto$. Lat. .. Depr. :: $\propto$.. Tangent Course
 _____ 60 _____ 30 _____ T. 45 _____ S. 26°. 20'. West.

As S. C. $\propto$:: Departure Distance.
 _____ S 26°. 20' _____ S. 90 _____ 30 _____ 62 Leagues

By which is found the Course (or Bearing) from the
 Ship to the Port is, S. 26° : 20' W. or S. S. W. 3° : 5'
 Westerly. Distance to run, 62 Leagues.

Thus

Thus you see *Traverse* is wrought by the 1st and 6th Case of *Plain-Sailing*; and therefore I shall leave it to the Learner to work it by our other Methods, by the Pen, &c.

And proceed to *Plain-Sailing* rectified by the Globe, call'd *Mercator's Sailing*; altho' indeed it was the Invention of Mr. *Wright*; but, *Mercator* stole the Invention from the Author, and publish'd it in his own Name.

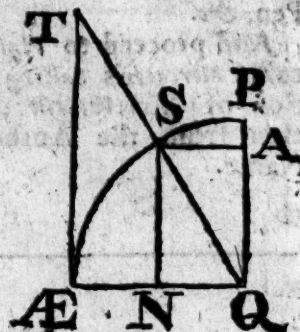
2. Of *Wright's Chart*.

THIS Chart shews, in any assigned Course, the Ship's Motion on any imaginary Plain, and the Meridians are parallel to one another, as in the Plain Chart; and divide the Equator into equal Parts, or Degrees, cutting it and the Parallels of Latitude at Right-Angles; but the Divisions of the Meridians (by the Circles or Parallels of Latitude) are not equal, as in the plain Chart, but unequal, and do continually increase from the Equator towards both Poles; that is, the Parts of the Meridian at every Point of Latitude must increase as the Secants of these Latitudes; so that the Points of Latitude at each Parallel must be protracted in like proportion with those of Longitude; and therefore the said Author makes his Chart by this Proportion; as the Radius of the Parallel (or Sine-Comp. of Lat.) is to the Radius of the Equator; so is a Degree of the Equator, to a Degree of Latitude so protracted: As to be represented in the Chart at such a Distance from the Equator; that is, always in such Proportion as is that of the Secant of the Latitude to the Radius. See the following Scheme.

Q

Construction.

Let Æ P. B be $\frac{1}{2}$ of the Meridian of the Globe, Æ Q the Semi-diameter, P the North or South Pole, A the Radius of any Parallel of Lat. which is to the Semi-diameter of the Equator, as the Sine of the Arch PS to the Sine of the Arch $P\text{Æ}$; i. e. as Æ Q to $Q N$. Draw the Sine SN and its Co-sine SA , also the Tangent Æ T , and Secant QT . Then $Q\text{Æ} = QS$ is the Radius.



Demonstration.

As Co-sine .. Rad. :: Rad. .. Secant; i. e.

As $NQ (= SA)$.. $QS :: Q\text{Æ} .. QT$.

Thus Mr. Wright did by the continual Addition of the Secants of $1' 2' 3' 4' 5'$, &c. form a Table of meridional Parts, for the Division of the meridional Line, beginning at the Equator or Parallel $00^\circ : 00'$, and continuing successively to the Poles of the World. So the Learned Dr. Wallis has demonstrated in *Philos. Transf.* N^o. 176. That the Distance and Position of any Parallel (representing the Lat. in the Chart) from the Equator shall be to a similar Arc of the Equator (equal to the given Lat.) as the aggregate of all the Secants in the Arc, to so many times the Radius.

But how to compute independently the meridional Parts answering to any given Lat. or the interval between any two, was not known till the meridional Line (or Sum of the Secants) was found to be analogous or proportional, to a Scale of Logarithmic Tangents, of half the Complements of the Latitudes. Which was first discovered by Chance, and afterwards proved by Mr. James Gregory, in his *Exercitationes Geometricae*; But with such a Train of Consequences, and Complication of Proportions, that the Evidence of the Demonstration was in a great Measure lost, and the Reader tired before he attained it.

Since which that excellent Mathematician Dr. Halley in *Philos. Transf.* N^o. 219. has also proved, that the Sum of the Secants or meridional Line on the Chart is not only

only proportionable to the Scale of Logarithmic Tangents, but that the meridian Line is also a Table of the Difference of Longitude, to each Minute of Latitude on the fourth Rhumb making an Angle of 45° . with the Meridian; wherefore the Scale of Logarithmic Tangents is a Table of the Difference of Longitude, to the several Latitudes upon some determinate Rhumb, Hence it follows, that as the Tangent of any other Rhumb; so is the Difference of the Log. of any two Tangents, to the Difference of Longitude on the proposed Rhumb, intercepted between the two Latitudes, whose half Complements the Logarithmic Tangents did represent. Now if we put Unity for one Minute of Longitude, as in the common meridian Line; because the Length of the Arch of 1 Minute, is 000290888, &c. and the Index of the Brigg's Logarithms 230258, &c. it will be,

As 230258, &c. to 290888, &c. So is the Radius to 1,263114, &c. The Natural Tangent of $51^{\circ} 38' 9''$. the Angle which the Rhumb-Line makes with the Meridian, under which the common Table of Tangents, are the true Differences of Longitudes.

Wherefore as 1263. to 1 Minute; so is the Difference of the Log. Tangents of half the Comp. of the Latitude of any two Places, to their meridional Difference Lat. in Miles. If there be a meridian Line, and a Line of artificial Tangents, both graduated from the same Line of equal Parts, a Degree or Minute upon the Line of Tangents shall be double to a Degree or Minute upon this meridian Line, and the artificial Tangent of one Minute (omitting the preceding Figures) is 2527, which by the foregoing Reason is equal to two Minutes upon the meridian Line; therefore the half of 2527 is 1263. which will be equal to one Minute on the meridian Line.

By what hath been said, it is easy to conceive how to make a Table of meridional Parts; or to find the meridional Difference, of Latitude (or Latitude enlarg'd) between any two Latitudes, as shall be shewn a little further.

To render the Idea of the Contrivance of (the Mercator's, or) Wright's Chart more perceptible to the Learner, I shall use the Author's own Illustration, which is as followeth, viz. "If a Globe with all its Meridians and Parallels posited in a concave Cylinder, (their Axis mutually agreeing) be supposed to be blown

“ like a Bladder, till every Part of the convex
 “ Superficies of the Globe touch every Part of the
 “ concave Cylinder ; then shall each Parallel upon the
 “ Globe attain an equal Diameter with the Equator
 “ or Cylinder : And then shall the Meridians upon the
 “ Globe be every where so far distant each from the
 “ other, as they were at the Equator ; and by this
 “ Contrivance will each Part in this concave Cylinder
 “ mutually agree with its corresponding Part in the
 “ Globe without either sensible or explicable Error.
 See *Wright's Correction of Errors* (in the *Sea-Chart*, or
Nautical Planisphere) Page 9.

To make the Mercator's Chart.

To Project the (so call'd) Mercator's Chart, for
 all, or Part of the Globe's Superficies.

1. **F**OR the *General Chart* : It is projected upon a Plain,
 the Meridians being parallel to each other,
 (which on the Globe do incline, and meet in the Poles)
 yet the Parallels of the Latitude are contrived so at
 unequal Distances, that in this Projection the Rhumbs
 are right Lines, and the Degrees of Longitude bear the
 same Proportion to the Degrees of Latitude in any Pa-
 rallel, that they do upon the Globe : Now to make a
 Chart to represent one half the Superficies of the Globe
 or near it ; (for you cannot go quite to the Poles, be-
 cause there the Quantity of one Degree of Latitude is in-
 finite) you may make Use of the Meridian Line, with
 the Line of equal Parts, (the two lowest Lines upon
Gunter's Scale.) Having provided a Sheet of Paper al-
 most as broad as long, (*viz.* the Breadth to contain the
 180 equal Parts annexed to the meridian Line on the
 said Scale) draw a Line cross the Middle of it
 that may contain 180 equal Parts from the Scale ; this
 Line so graduated shall represent the Equinoctial, and
 the Divisions 180 Degrees of Longitude. Draw Lines
 along each Edge of the Equinoctial perpendicular, or
 at right Angles to it, and let these Lines be graduated
 upwards and downwards from the said Equinoctial, by
 the Divisions of the meridian Line, to about 89 De-
 grees of Latitude on each Side of the Equinoctial :

Then

Then draw Lines through every 10° . of these unequal Divisions parallel to the Equinoctial: and likewise draw Lines through each 10° . of the Equinoctial, and perpendicular to it, so will these Meridians last drawn intersect the Parallels first drawn in every 10° . of Latitude and Longitude.

Then at each Corner of your Chart, you may describe an Arch or Quadrant, and divide it into eight equal Parts, and draw from the Centers Rhumb-Lines through the Chart, noting the North Point of the said Quarters with the Flower-de-Luce.

And lastly, to lay down any Island, Headland or, given Place, whose Latitude and Longitude is known by your Observation, or approved Tables of Latitude and Longitude. — Take a Pair of Compasses, and with one Foot in the Latitude of the Place on the graduated Meridian, extend the other Foot to the nearest Parallel or East and West Line, and there let them remain; then with another Pair of Compasses, and one Foot in the Longitude of the Place upon the Equinoctial, extend the other to the nearest Meridian, (or North and South Line;) then running each Pair of Compasses along their respective Lines towards each other, the moveable Points will meet in the given Longitude and Latitude, or Point where the Place given is to be laid down; and by two such Charts as these, (which together make a Square) you may represent all the Superficies of the Earth, except above five Degrees of Latitude under each Pole.

To make a Chart for a particular Voyage.

This Chart is much better than the former, for the Mariner's Use, because the Gradations may be much larger; and to make it more accurately, we shall use the Table of meridional Parts.

Example. Let it be required to make a Mercator's Chart for a particular Voyage, viz. from the Lizard in Latitude $49^{\circ} 55'$ N. to Ansegon, in Latitude $17^{\circ} 45'$. (or for any of the *Leward Caribee Isles*) Difference of Longitude $54^{\circ} 07'$ West, or 3240 Miles, the meridional Difference of Latitude between these two Places being found (by the Tables) to be 2471 Miles.

Take
18.7

Take a Sheet of strong Paper, as large as you intend your Chart shall be; then chuse some Scale of equal Parts, of which 3240 may be the Breadth, and 2471 the Length or Depth, with a convenient Allowance for Ruling, or what you think fit to draw for Ornament about the outside of it: Then towards the North East (or upper right Hand) Corner, because your Course is South Westerly,

Assume a Point (L) for the *Lizard*, and draw a Line right down the Chart for the Meridian of the *Lizard*, upon which set the meridional Difference of Latitude 2471 from the *Lizard-Point* down the Meridian, to a Point N. on which erect a Perpendicular to the Westward, and set off the Difference of Longitude 3240 from N. to M. and this Line, (if you will make the Chart to the Equinoctial) you may divide into every Degree, or every 2°. Degrees, or equal Parts; finish your Oblong, with the other two Sides or Limits of your Chart. Draw a Line down the Middle of your Chart, for the Meridian (to be graduated) which you must thus divide the meridional Parts (or meridional *n. Lat.*) between the *Lizard's* Latitude 49°. 55'. and next lesser Degree, *viz.* 49°. is 85 equal Parts set off on the said Meridian, from the Parallel of the *Lizard* or Top of the Chart downward for 49°. of Lat.

Again, find the meridional *n. Lat.* between 49°. 55', and 48°. which is 175 min. and set it off from the said Point of parallel on the Meridian downward, and it shall mark out the 48°. of Lat. and so proceed with the rest, which you may number with Figures on the graduated Meridian, and thro' every 5° or 10° draw Lines parallel to the Top or Bottom of your Chart, for the Parallels of Latitude; and for the other Meridians, draw Parallels to the Sides of the Chart, or to the graduated Meridian thro' every 5° or 10° of Longitude, on the Bottom, or Equinoctial Line. And you may describe the Rhumbs or small Compass Cards, at any Places or Corners of the Chart. And then, lastly, for laying down any Head-Lands, you may, by the Directions given in making the general Chart, lay them down in their proper Places. And these Charts are much more convenient for the Navigator's Use than even the Globe itself, on which the Rhumbs are Spirals, or crooked, and the Distances of Places the Arch of a great Circle. I therefore proceed to the Use of this Chart in Navigation. And,

1. To find the Latitude of any Place in the Chart.

2. To find the Course or Bearing of any two Places in the Chart.

These two Problems are performed the same way on this Chart, as before shewn in Prob. 1. and 3d. of the Use of the Plain Chart, and needs no Examples.

3. To find the Longitude of any Place in the Chart.

Rule. 1. Take the nearest Distance from the proposed Place to any Meridian. 2. Move the Compasses (being kept at that Distance) with one Foot on the Meridian, till both Feet come on the Equinoctial, and the Foot which stood on the proposed Place sheweth its Longitude requir'd. So the *Lizard*, by this Rule, will be found in Longitude of $5^{\circ} : 23'$ West, if the Longitude is counted from the Meridian of *London*, but in $00^{\circ} : 00'$ if counted from the Meridian of the *Lizard*.

4. To find the Distance of any two Places in the Chart.

This admits of four Cases, *viz.* 1. When the two Places are under one Meridian, that is, bear North and South of each other.

Rule. Find the Latitudes of the two Places by Prob. 1. of this Chart, and then the Difference of Latitude between them, as found in Page 35, is the Distance required. So that the Distance between Cape *St. Vincent* in *Spain*, in Latitude $37^{\circ} : 15'$ N. and Cape *Tantim*, in *Barbary*, Lat. $32^{\circ} : 42'$ N. is $4^{\circ} : 33'$ or 273 Miles.

2. When two Places are upon the Equator or Equinoctial, (they bear East or West) to find their Distance.

Rule. Find the Difference of Longitude between them, (as is shewn a little farther) and it's the Distance required. This is so easy, that it needs no Example.

3. When the two Places bear East and West in one Latitude or Parallel, to find their Distance.

Rule 1. Take the Distance between the two Places in the Compasses. 2. Lay that Distance on the graduated Meridian, so that one Foot may be as many Degrees above the Latitude of the given Place, as the other below it; there stay the Compasses. 3. Count the Degrees between the Feet of the Compasses, and it's the Distance required.

Or thus: Take the Length of a Degree in the given Latitude; turn that over in a straight Line from one Place to another, as many times as you can, gives the Number of Degrees for the Distance as before. So Cape Roxant, going into *Lisbon*, and the *Isle Pico* one of Western Isles, being both in the Latitude of 38° ; will be found by the former Rules to be 13° . or 266 Leagues distant.

4. When two Places differ both in Latitude and Longitude, to find their Distance.

Rule 1. Take their Difference of Latitude from the Equinoctial.

2. Lay a Ruler on both the given Places, apply that Distance so to the Ruler's Edge, that when one Foot is placed close to the Ruler, and the other turned about, it may just touch some East and West Line cross'd by the said Ruler's Edge; there stay the Compasses.

3. Then the Distance (by the Ruler's Edge) from the Place where the Compasses rested, to the Place where the Ruler crosseth the aforesaid East and West Line measured on the Equinoctial, giveth the Distance required.

Thus to find the Distance from the *Lizard* to *Antegoa*.

The <i>Lizard's</i> Latitude is	_____	49 : 55 N.
<i>Antegoa's</i> Latitude is	_____	17 : 15 N.
Their π . Latitude is	_____	32 : 40

Which taken in your Compasses from the Equinoctial, (and the Ruler laid over the *Lizard*) and applied as before, and measured on the Equinoctial again, gives $56^{\circ}24'$. or 1144 Leagues the Distance required.

5. The Latitude and Longitude of the Ship given, to find the Point, or Place of the Ship represented in the Chart. This is of great Use to shew the Mariner what Headland or Islands are near him in his Voyage, &c. and this Problem is performed after the same manner as was directed in Page 74. of laying down any Headland or Place on the general Mercator's Chart; therefore if we suppose when at Sea, you find by your Journal or Reckoning (at Noon) you were in the Latitude of $40^{\circ}30'$. North, and

Lon.

Longitude from *Lizard* $17^{\circ} 20'$ (or from the Meridian of *London* $22^{\circ} 33'$ W. according to which Meridian of the two you count Longitude from) by the foresaid Rule, the Ship will be found at the Point D, near unto the *Azores*, or Western Islands *Tercera, Gratijsa, &c.*

Thus may you prick down the Place of your Ship any (or every Day) at Noon; and drawing Lines from Point to Point, from the Place you departed from, (with a Black-Lead Pencil, which may be wiped out at Pleasure) you will have the Tract the Ship hath made at the End of every 24 Hours during the whole Voyage.

The finding the Distance of two Places differing in Latitude and Longitude, with a little Practice, will be found very easy; but, to make it yet more quick and easy in Practice, some Authors have oblig'd us with Scales for measuring the said Distance in a Mercator's Chart; as Capt. *Sturmy's Magazine*, Page 120. Mr. *Wilson's Addition to Practical Navigation*, Page 187. Mr. *Hafelden's Description and Use of Mercator's Chart*, Page 27. but I conceive that they are of no Use at all to the Mariner, except they were inserted in every particular Mercator's Chart the Mariner buys.

I pass on to (Mercator's, or rather) *Wright's Sailing by Construction and Calculation.*

Primary Problems.

Prob. 1. Given, the Latitude of two Places; required the meridional Difference of Latitude between those two Places.

WE shall solve this Problem, both by the Table of meridional Parts, and Table of Log. Tangents, the one being the certain Proof of the other.

1. To find the meridional Parts out of the Table of meridional Parts for any Latitude.

I demand the meridional Parts for the Latitude of $49^{\circ} 55'$ (North or South) right against 49° (in the first

first Column) and under 55 Min. (at the Head of the Table) you will find 3467 is the meridional Parts in Miles, answering the Latitude as was required.

Since this Table is calculated but to every five Minutes or Miles of Latitude, you have at the End of it annex'd a Table of proportional Parts, by the Help of which you may find the meridional Parts to every Minute of Latitude.

Example. *What's the meridional Parts for the Latitude of 16°. 29'?*

The next less than 29. is 25; wherefore finding the meridional Parts for 16°. 25 to be 999, and right against 16 Degrees in the Column of the Difference you will find 5; look this Difference in the first Column under (D) of the Table of Proportional Parts, and find 4 (the Difference between 29. and 25.) at the Head of the Table; then right against 5, and under 4 you will find the proportional Part 4; which added to 999, makes 1003, the meridional Parts for the Latitude of 16°. 29' required.

Then observe this Rule.

Latitudes both North or both South, subtract; but one Latitude North, and the other South, add the meridional Parts, and the Difference or Sum is meridional Latitude required.

Example. 1. *What's the meridional Latitude between the Lizard, Latitude 49°. 55'. North, and Madera in Latitude 32°. 25'. North.*

	Merid. Parts
From _____	3467
Subtract _____	2658

Rem. is merid. Lat. 1409 Miles

By the Log. Tangents.

Rule. The Diff. of the Tangents (or Co. Tangents) of half the Comp. Latitudes divided by 1263, gives the meridional Latitude in Miles.

Lat. { Lizard 49 : 55 }	Co. 20 : 02	1.9561871
Lat. { Madera 32 : 25 }	Lat. 28 : 47	1.9739876
		Diff. = 178019

(1263) 178019. (1409 meridional Latitude)

Exam.

Exam. 2. If one Place hath a Lat. the other none; (shop-
is, on the Equator) Suppose Surat and the Island St. Thomas,
what is their Merid. $\times$. Latit.

				Miles
Lat. {	Surat	21 : 10 N.	} Meridional	1300
	St. Thomas	00 : 00		
Remainder = meridional $\times$. Latitude				1300

By Log. Tangents.

Rule. The Diff. between the Tangents (or Co. Tan-
gents) of half the Comp. Lat. and the Tang. of 45°
(= Radius or 10.000000.) divided by 1263, gives the
meridional Difference of Latitude in Miles.

Lat. {	Surat	21 : 10 Co. Lat. 34 : 25	9.835780
	St. Thomas	00 : 00 T. 45° .00	10.000000
Diffs. =			164220
1263) 164220 (1300 = merid. $\times$. Lat.			

Exam. 3. In Latitudes of different Kind (one North the o-
ther South) suppose Antegoa, and Cape Bon. Esperance, What
is their merid. $\times$. Lat.

To 1051	} Merid Parts	{	Antegoa	17 : 15 N $^\circ$.
Add 2192			in Lat.	C. Bon. Esp.
Sum 3243 = meridional $\times$. Latitude required.				

By Log. Tangents.

Rule. The Sum of the Difference between the Tang.
 45° and the Tang. (or Co. Tang.) of half Co. Lat.
divided by 1263, is equal to the meridional $\times$.
Lat.

Lat. {	Antegoa	17 : 25	} $\frac{1}{2}$ Co	{	36 : 22	10.132906
	C. B. Esp.	34 : 15			Lat.	27 : 32
Sum =						409674
1263) 409674 (3243 = meridional $\times$. Lat. required.						

The Merid. $\times$ Lat. may be also found by Gunter's Scale, Thus;

The Extent of the Compasses from one Lat. to another, on the meridian Line, will give meridional $\times$ Lat. in Deg. and Min. on the Equinoctial Line, or Line of equal Parts. That multiplied by 60, adding the odd Minutes (if there be any) gives the meridional $\times$ Latitudes in Miles.

Prob. 2 Given the Longitude of two Places; required their Difference of Longitude?

Rule. In Longitudes of the same Name (that is, both East or both West) their Difference; but of contrary Names (that is, one East & other West) their Sum is the Difference of Longitude required.

Note. If that Sum exceed 180° . subtract it from 360° . and the Remainder is the Difference of Long.

Exam. 1. What's the Difference of Longitude between Madera Isle, and the Island of Antegoa?

From	} the Longitude of {	Antegoa	61 : 44 W.
Subt.		Madera	17 : 42 W.
Remainder = $\times$ Longitude required		44 : 02	
		60	

Or reduced is = 2642 Miles.

Exam. 4. Required the $\times$ Longitude between Barbadoes and Cape Negro?

To	} the Longitude of {	Barbadoes	58 : 32 W.
Add		Cape Negro	14 : 26 E.
Sum = $\times$ Longitude required		72 : 58	

Exam. 3. Required the $\times$ Longitude between the River Canton in India, and the West-end of Jamaica in the West-Indies?

To	} the Longit. of	{ R. Canton	114 : 00 E.
Add			{ Jamaica
			Sum 191 : 12
			Subtract from 360 : 00
Remainder is = x. Longitude			168 : 48

Prob. 3. Given the Longitude of one Place, and the $\times$ Longitude between that and another; required the Longitude of that last Place?

Rule, Case. 1. If the given Longitude and $\times$ Longitude be of the same kind, (*viz.* both East or both West) their Sum is the Longitude required of the same Name with the first Place.

Note. If the Sum be more than 180° : its Complement to 360° is the Longitude requir'd, of contrary Name with that of the first Place.

Case. 2. But if the given Longitude and $\times$ Longitude be of different kind, (that is, one East and the other West,) their Difference is the Longitude required of the same Name with the greatest.

Exam. 1. Suppose from the Longitude of the Lizard $50^\circ. 23' W.$ a Ship sails Westerly, till her $\times$ Longitude be $35^\circ. 45' W.$ I demand the Longitude she is in?

By Case 1.

To the departed	} Longitude	{	5 : 23 W.
Add the Diff.			35 : 45 W.
Sum is the present			41 : 08 W.

Exam. 2. If from the Longitude of $143^\circ. 20' W.$ a Ship sails Westerly till the $\times$ Longitude be $55^\circ. 40' W.$ what Longitude is she in?

By Case 1.

To the departed } Longitude { 143 : 20 W.
Add the Diff. of } { 55 : 40 W.

Sum is 199 : 00

Subtract from 360 : 00

Rem. = present Longitude 161 : 00 E.

Exam. 3. Suppose from the Longitude of $56^{\circ} 30'$ W. a Ship sails easterly, till the Difference of Longitude be $33^{\circ} 45'$ E; I demand the present Longitude?

By Case 2.

From departed } Longitude { 56 : 30 W.
Subtract Difference } { 33 : 45 E.

Rem. = present 22 : 45 W.

Prob. 4. Case. Given, the Latitude and Longitude of two Places, required their Course (Bearing) Distance and Departure (or meridional Distance.)

Exam. A Ship takes her Departure from the Lizard in Latitude of $49^{\circ} 55'$ N. and $5^{\circ} 23'$ W. Long. being bound to Antegoa in Lat. $17^{\circ} 15'$ N. and Long. $61^{\circ} 44'$ W. what Course must she steer, and what Distance (and Westing) must she make upon a strait Line to the Island?

Preparation.

From 49 : 55 { } Liz. { M. { 3467 { 66 } 5 : 23 W.
Subt. 17 : 15 { } Ant. { P. { 1051 { 61 } 61 : 44 W.

Rem. 32 : 40 Mer. x. Lat. = 2416 56 : 21

60 Take $\frac{1}{2}$ 805 Lg. 60

m 1960 = x. Lat.

3) 653 Leagues

x. Long. 3311 m.

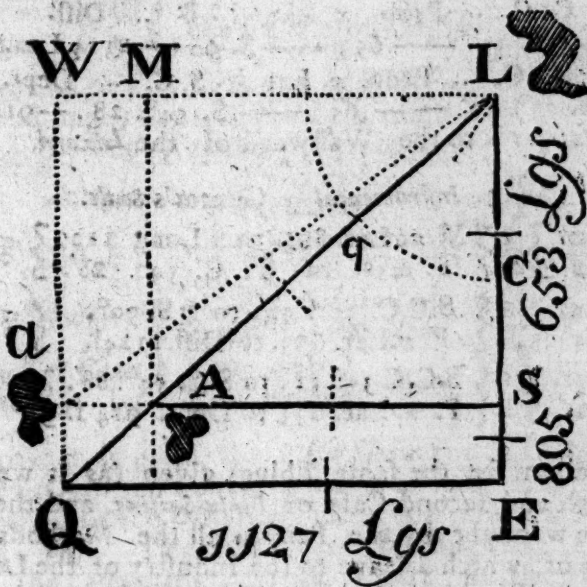
3) 1127 Lgs:

I. Con-

1. Construction Geometrically.

Draw LE for the Meridian of the *Lizard*, and on it from L. set off the meridional $\times$ Lat. $80\frac{1}{2}$ l. from L. to S. *E*

27 Erect a Perpendicular from E towards Q, and set on it from E the π . Long. 1127 l. (= Parts) to Q, and draw the Line Q L.



3. Draw from S-S A. parallel to the x . Longitude

4. With a Chord of 60° on the Point L. describe an Arch eg .

Explanation. A represents *Antegon*, L the *Lizard*, S A the *Departure*, L A the *Dist.* the *Arch* ϵq , or $\angle$ at L the *Course* (S° . westerly) from the *Lizard* to *Antegon*.

Mensuration. L A and S A measured on the equal Parts severally, gives 1124 l. for the Distance, and 914 l. for the Departure; also the Arch *c.g.* measured on the Chords, gives S. 54°. 28'. W. for the Course, from the *Lizard* to *Antegoa* by *Mercator's* or the true Chart.

2. Logarithmically.

(As the sixth Case of *Plain-Sailing*)

As Mer. $\times$ Lat. $\therefore R :: x$. Long. T. Course.
~~805~~ — 805 — T. 45 — 1127 — ~~S. 54°~~, 28'. W.

Then as in Case 2. *Plain-Sailing*.

As S. C. C. $\therefore$ Prop. $\times$ Lat. $:: R ::$ Dist.
 — S. 35°. 32'. — 653 — S. 90 — 1124 Leag.

As S. C. C. $\therefore$ Prop. $\times$ Lat. $:: S. C. ::$ Depr.
 — S. 35°. 32'. — 653 — S. 54°. 28'. — 914 Lgs
 that *Antegoa* is to the Westward of the *Lizard*.

3. Instrumental by Gunter's Scale.

The Ext. } from { M. $\times$ Lat. 805. to $\times$ Long 1127. } $\frac{8}{5}$ { Nrs
 reaches } from { T. 45°. to T. C. 54°. 28'. } $\frac{8}{5}$ { T's
 The Ext. } from { S.C.C. 35°. 32'. to $\times$ S. 90°. } $\frac{8}{5}$ { Snes
 reaches } from { P $\times$ Lat. 653. to Dist. 1124. } $\frac{8}{5}$ { Nrs
 The Ext. } from { S.C.C. 35°. 32'. to S.C. 54°. 28'. } $\frac{8}{5}$ { Snes
 reaches } from { P. $\times$ Lat. 633 to Depr. 914 1. } $\frac{8}{5}$ { Nrs

Here you see the same Things given (as it were) in the sixth and second Case of *Plain-Sailing*, and therefore may be wrought by the Pen, in all the Methods there treated of, which I leave to the Industry of the Learner, as I shall also the following Case; only you may observe, that in this and other Cases of *Mercator's Sailing*, we have two similar Triangles to solve; and therefore by 4.6. *Euclid*. they are proportional, like Sides to like Sides. For as L E (the meridional $\times$ Lat.) is to E Q (the $\times$ Long) so is L S. (the Prop. $\times$ Lat.) to S A (the Depr.) the Course and Distance is found (*Arithmetically*) by Case 6. of *Plain-Sailing*.

Use of this Case, is when we depart from any Headland, &c. to know the Course and Distance to any other Place; which is required at the Beginning of your Voyage, and of the keeping your Sea-Journal.

We shall in this Problem also shew the Defects of the *Plain Chart* or *Plain-Sailing*, and exhibit the Verity the *Mercator's Chart* or *Plain-Sailing* rectified by the Globe.

Construction. Make $Sa = EQ$ (because the κ . Longitude and Departure, are the same thing in Plain-Sailing) and draw La ; draw also from A and a , AM . and aW , parallel to LE .

Explanation.

LE } the Meridian of { the Lizard,
 MA } Antegoa
 LW } the Parallel of Lat. of { the Lizard,
 SA } Antegoa.

L . S. κ . Lat. 653 l. L . E. the Merid. κ . Lat. 805 l. and E Q. κ . Long. 1127 l. by Mercat. and $Sa = 1127$ l. the κ . Long. (or Depr.) by the Plain Chart.

A } Antegoa by { Mercator's
 a } the Plain
 LA } Dist. { 1124 } by { Mercator's
 La } { 1303 } { the Plain
 SA } Depr. { 914 } by { Mercator's
 Sa } { 1127 } { the Plain

ALS } L L A S } Course { Mercator's } Chart { S. 54 : 28 W
 LS } L a S } by { the Plain } Chart { S. 59 : 55 W

So that it is plain, the *Plain Chart* (or *Plain-Sailing*) is erroneous, in the Course $5^{\circ} 27'$. or half a Point more Westerly; in the Distance 79 Leagues, and in the meridional Dist. Departure or Westing 213 Leagues, from the *Mercator's* or true Chart in the forefaid Voyage.

Prob. 5. Case 2. Given Latitudes and Course; required Dist. Depr. and κ . Long.

Exam. Sailing by the Log. (since Yesterday) Variation and Lee-Way, &c. (allowed for) S. W. by W. and the Latitude of Yesterday was $48^{\circ} 50'$. N. and to Day by Observation the Ship is in Lat. $47^{\circ} 10'$. N. What is the Distance run, Departure (or Westing,) and κ . Longitude?

Prep. From $48 : 50$ N } Merid. Parts { 3367
 Subtr. $47 : 10$ N } { 3217

$1 : 40$

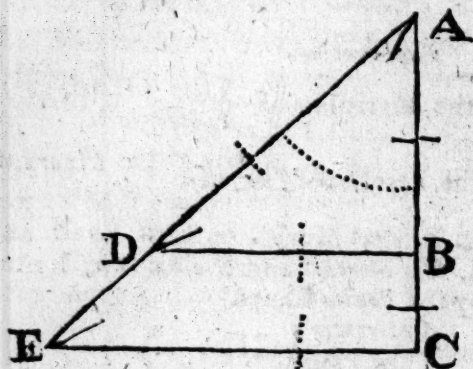
Mer. κ . Lat. = 150 m

κ . Lat. = 100 m.

G 3

Con.

Construction.



1. Construct the Triangle ABC by the Course and $\propto$ Lat. according to the second Case of *Plain-Sailing*.

2. Make AC equal to the meridional $\propto$ Latitude $150m.$ ($=$ Parts,) and draw EC (the $\propto$ Long.) parallel to DB the

Departure, till it meet the Distance $A'D$ produced in E . Then is AD the Distance sailed $= 148m.$ $BD =$ the Departure $150m.$ and $CE = 224m.$ the $\propto$ Longitude, when measur'd by a Scale of equal Parts.

As Case 2. *Plain-Sailing, Calculation by Logar.*

As $S. C. C.$.. $P. \propto$ Lat. $:: R.$.. Distance
 $\text{--- } S. 33^{\circ} 45' \text{ --- } 100m. \text{ --- } S. 90^{\circ} \text{ --- } 178 \text{ Miles.}$
 2. As $S. C. C.$.. $P. \propto$ Lat. $:: S. C.$.. Depr.
 $\text{--- } S. 33^{\circ} 45' \text{ --- } 100m. \text{ --- } S. 56^{\circ} 15' \text{ --- } 150 \text{ mil.}$
 3. As $S. C. C.$.. Mer. $\propto$ Lat. $:: S. C.$.. Long.
 $\text{--- } S. 33^{\circ} 45' \text{ --- } 150m. \text{ --- } 56^{\circ} 15' \text{ --- } 224 \text{ Miles.}$

Or,

As $R.$.. Mer. $\propto$ Lat. $:: T. C.$.. $\propto$ Long.
 $T. 45^{\circ} \text{ --- } 150 \text{ --- } 56^{\circ} 15' \text{ --- } 224 \text{ Miles.}$

Or,

As $P. \propto$ L. .. Mer. $\propto$ Lat. $::$ Depr. $\propto$ Long.
 $\text{--- } 100m. \text{ --- } 150 \text{ --- } 150 \text{ --- } 224 \text{ Miles.}$

3. *Instrumental by Gunter's Scale.*

The Ext. } from { $S. C. C. 33^{\circ} 45'$ to $R. S. 90^{\circ}$ } $\frac{100}{178}$ } Sns.
 reaches } { $P. \propto$ Lat. $100m.$ to Dis. $178m.$ } $\frac{100}{178}$ } Nrs.
 The Ext. } from { $S. C. C. 33^{\circ} 45'$ to $S. C. 56^{\circ} 15'$ } $\frac{100}{150}$ } Sns.
 reaches } { $P. \propto$ Lat. $100m.$ to Dep. $150m.$ } $\frac{100}{150}$ } Nrs.
 The Ext. } from { $S. C. C. 33^{\circ} 45'$ to $S. C. 56^{\circ} 15'$ } $\frac{150}{224}$ } Sns.
 reaches } { Mer. lat $150m.$ to $\propto$ Long $224m.$ } $\frac{150}{224}$ } Nrs.

Prob. 6.

Prob. 6. Case 3.

Given Latitudes and Distance; required Course, Departure, and $\propto$. Longitude, sailing North-westward from Cape St. Vincent in Portugal 300 Miles, until by Observation the Ship is in Lat. $41^{\circ}.00'.N$. What's the Course steer'd, Departure, and Longitude the Ship is in?

Preparation.

Mer. Parts Longit.

From $\left\{ \begin{array}{l} 41 : 00 \text{ N.} \\ 37 : 15 \text{ N.} \end{array} \right\} \text{Lat. } \left\{ \begin{array}{l} 2702 \\ 2411 \end{array} \right\} \left\{ \begin{array}{l} 10^{\circ}.35'.W. \\ 4 : 17 \text{ W.} \end{array} \right.$

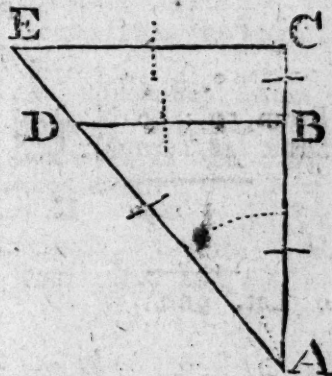
Miles $3 : 15$ Mer. $\propto$. Lat. 291 Long. $14 : 52$ W,

$225 = P. \propto$. Lat,

1. Construction,

1. With the $\propto$. Latitude $225 =$ Parts and Distance 300 $=$ Parts project the Triangle $A B C$ by Case 4. Plain-Sailing.

2. Let $A C$ be made equal to the meridional $\propto$. Lat. 291 $=$ Parts, and erect the Perpendicular $C E$ till it meet with $A D$. continued in E ; then is $B D$ the Departure $=$ to 198m. and $C E = 257m.$ being measured on the Scale of equal Parts; also the Angle $B A D$ the Course, the Arch of which Angle, on the Chords is $= 48^{\circ}.35'.$



2. Logarithmetical, By Case 4. P.S.

As Dist. $\propto R :: P. \propto$. Lat. $\propto$ S. C. Course
 $\frac{300m.}{S. 90^{\circ}.}$ $\frac{225}{48^{\circ}.35'}$ Comp.
 to $90^{\circ}.$ is N. $41^{\circ}.25'.W.$ the Course steer'd.

As $R ::$ Dist. $::$ S. C. $\propto$ Departure.
 $\frac{S. 90^{\circ}.}{300}$ $\frac{S. 41^{\circ}.25'.$ $\frac{198m.$

As S. C. C. $\propto$ Mer. $\propto$. Lat. $::$ S. C. $\propto$ $\propto$. Long.
 $\frac{S. 48^{\circ}.35'.$ $\frac{291m.$ $\frac{S. 41^{\circ}.25'.$ $\frac{257m.$

to E; so shall DE be = the $\times$. Long. AC the Dist. the former = 193m. and the latter = 156m. when severally measured by a Scale of equal Parts; likewise the Arch of the Angle of the Course measur'd on the Line of Chords is = S. 54° . 2'. E for the Course required.

Logarithmetical by Case 6. Plain-Sailing.

As $\times$. Lat. .. R :: Depr. .. T. Course.
 — 90. — T. 45° . — 127m. — T.C. 54° . 30'. Er:
 As S. C. .. Depr. :: R .. Dist.
 — S. 54° . 0'. — 127m. — S. 90 — 156 Miles

Then by Case 2. Plain-Sailing.

As S.C.C. .. Mer. $\times$. Lat. :: S. C. .. Long.
 — S. 35° . 30'. — 138m. S. 54° . 30'. = 193 Miles or
 3'. 13'. which subtracted from 59. 23. W. Long. sailed
 from, gives 2'. 10'. W. Longitude the Ship is come
 into.

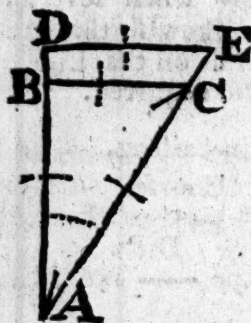
I judge it needless to set down any more Extensions by Gunter's Scale in this Sailing, since it's so obvious to a diligent Learner: If he observes the General Rule, of extending the Compasses from the first Term to the third, (in any Proportion) will reach from the second Term to the fourth Term required.

These four last Cases are only of use at Sea, (where we have always two Latitudes given;) but since it is customary, to work the other Cases wherein one Latitude only is given, I shall not omit them.

Prob. 8. Case 5. Given one Latitude, Course and Distance; required $\times$ Latitude, Departure, and $\times$ Longitude, &c.

A Ship from the Latitude of 15° . 15'. N^o. and Longitude 17° . 45'. W. sails N. E. by N. 120m. what Latitude is she in, and what's her Easting, and Longitude arrived into?

Projection.



1. With the Course 3 P. or $33^{\circ} 45'$ and Dist. 120m. Construct the Triangle A B C, by Case the first of *Plain-Sailing*, Meth. 1.

2. The Departure and $\times$ Latitude is measured as there directed. Then.

Logarithmic. by Case 1. *Plain-Sailing*,

As R .. Dist. $::$ S. C. C. .. $\times$ Lat.
 — S. 90 — 120m. — S. $56^{\circ} 15'$ — 100 Miles,
 or $1^{\circ} 40'$ Northerly. Then

To Latitude 15 : 15 N. — 926
 Add $\times$ Latitude 1 : 40 Northerly.

Z. = Latitude in 16 : 55 N. — 1030

104 = Mer. $\times$.

Lat. which set off from A to D, and draw DE parallel to BC, till it meet with AC. produc'd in E. so shall DE be the Alteration of Longitude. Then say;

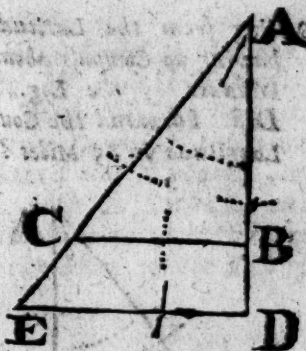
As R .. Dist. $::$ S. C. .. Depr.
 — S. 90 — 120m. — S. $33^{\circ} 45'$ — 67 Miles.

As S. C. C. .. Mer. $\times$ Lat. $::$ S. C. $\times$ Long.
 — S. $56^{\circ} 15'$ — 104m. — $33^{\circ} 45'$ — 69m. or
 $1^{\circ} 9'$ E; which deducted from $17^{\circ} 45'$ W. Longitude, the Remainder $16^{\circ} 35'$ W. is the Longitude the Ship is come into.

Prob. 9. Case 6. Given one Lat. Course and Departure; required the other Latitude Distance and $\times$ Longitude.

Admit a Ship in the Latitude of $50^{\circ} 00' N.$ and Longitude $5^{\circ} 30' W.$ sails S. W. by S. until she is in the Longitude of $6^{\circ} 55' W.$ I demand what Latitude she is come into, with her Distance and Departure from the Meridian?

Prop. From $6^{\circ} 55'$ take $5^{\circ} 30'$ remains $1^{\circ} 25'$ or 85 Miles for the $\propto$ Longitude. Then the Question is delineated, as in Case 3. of Plain-Sailing, Method 1. making DE equal to the $\propto$ Longitude, and the Angle DAE equal to the Complement of the Course.



Logarithmic. by Case 3. Plain-Sailing.

As S. C. $\propto$ Long. $\therefore$ S. C. C. Mer. $\propto$ Lat.

S. $33^{\circ} 45'$ — 85m. — $56^{\circ} 15'$ — 128m.

Then because the Ship sailed to the Southward from a North Latitude.

From the merid. Parts answering $50^{\circ} 00' N.$ 3475
Take the meridional $\propto$ Lat. Southerly — 128

Remains the merid. Parts of the Lat. the } 3347
Ship is in $48^{\circ} 37'$ as found in the Table
of merid. Parts.

Then from Latitude — $50 : 00 N.$

Subtract the Lat. come into $48 : 37 N.$

Remains the $\propto$ Latitude — $1 : 37$ or 83m

Then make AB equal to the Prop. $\propto$ Lat. 83 equal Parts, and draw BC the Departure, parallel to the $\propto$ Longitude DE, and the Question is projected.

The Dist. and Departure is found Logarithmic. by Case 2. Method 1. of Plain-Sailing, viz.

As S. C. C. $\propto$ P. $\propto$ Lat. $\therefore$ R. Dist.

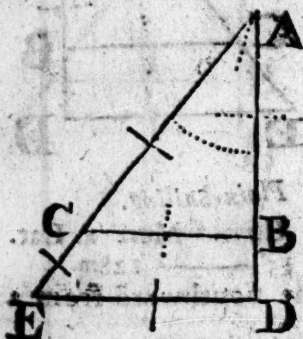
S. $56^{\circ} 15'$ — 83m — S. 90° — 100 Miles.

As S. C. C. $\propto$ P. $\propto$ Lat. $\therefore$ S. C. Depr.

S. $56^{\circ} 15'$ — 83m — S. $33^{\circ} 45'$ — 55 Miles

Prob. 12. Case 9. Given one Lat. Dist. and $\times$. Longitude, required the other Lat. Course and Departure.

Sailing from the Latitude of 50° N°. South-westerly 100m. having no Compass aboard that was good; but knowing my Distance by the Log. to be 52m. less than the Mercatoral Dist. I demand the Course Lat. in, and Departure; the $\times$. Longitude is 85 Miles?



With the $\times$. Longitude 85 = Parts, and Mercator's Dist. 152 = Parts project the Triangle ADE. By Case 5. Plain-Sailing, Method 1. Then, by the said Case, 'twill be to find the Course by the Logarithms Thus;

As Merc. Dist. .. R :: $\times$. Long .. S. Course.
 — 232m. — S. 90 — 85m. — S. $33^{\circ} 45'$ W.
 Make AC = 100 Parts and draw CB parallel to DE, so shall CB be = Departure and AB = $\times$. Lat. Then by Case 1. Plain-Sailing

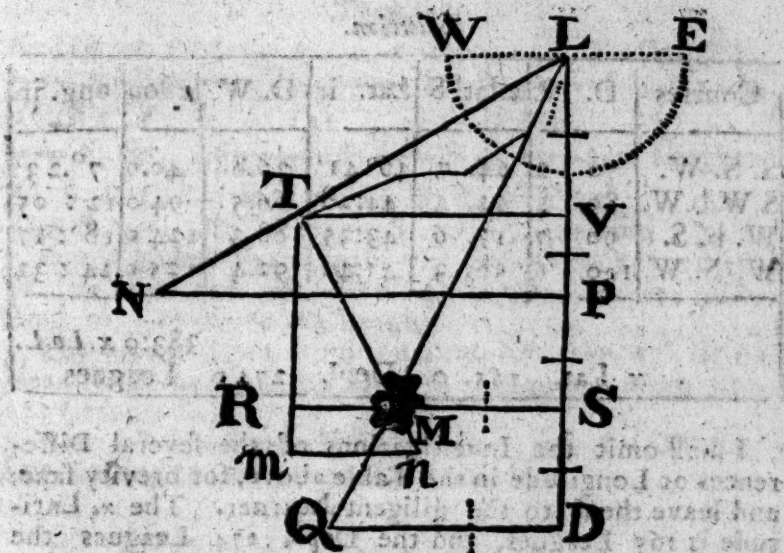
As R .. Dist. :: S. C. .. Depr.
 — S. 90 — 100m. — S. $33^{\circ} 45'$ — 55 Miles
 As R .. Dist. :: S. C. C. .. $\times$. Lat.
 — S. 90° — 100m. — S. $56^{\circ} 15'$ — 83m. or $1^{\circ} 23'$
 Then from 50° N°. Lat. Subt. $\times$. Lat. $1^{\circ} 23'$ Southerly, remains $48^{\circ} 37'$ N°. the Lat. the Ship is in.

Mercator's

Mercator's Traverse.

Prob. 13. Exam. 1.

A DMIT a Ship from the Latitude of (the Lizard) $49^{\circ} 55'$ and Longitude $5^{\circ} 23' W.$ is bound to Madera, in Lat. $32^{\circ} 23' N.$ and Long. $17^{\circ} 45' W.$ runs these Courses, viz. (1.) S. S. W. 70 L. (2.) S. W. by W. 80 Leagues. (3.) W. by S. 90 L. (4.) W. S. W. 100 Leagues. I demand the Bearings and Distance of the Lizard and Madera, and also the Course and Distance made; with the Latitude and Longitude the Ship is in; likewise the Bearings and Distance from the Lizard and Madera to the Ship, at the End of her Traverse.



Preparation.

Mer. Pts.

Lat. {	49 : 55 N. }	3467	{ Lon }	5 : 23 W.
	32 : 23 N. }	2058		17 : 42 W.
	17 : 30	(1409		12 : 19
	20			20
	M. n. Lat. 469 $\frac{1}{2}$			
	n. Lat. 350 Lgs.			
				n. Long, 246 Lgs.
				Course

Course S. $27^{\circ} 38'$ W. Dist. 395 Lgs. Departure 184 Leagues by Case 1.

2. With these given Things protract the *Mercator's* Triangle L D Q, by *Prob. 4. Case 1.* of this Sailing; so shall L represent the *Lizard* and M. *Madera*.

3. Project your Traverse with the given Courses and Distances, as is directed in the first *Plain-Sailing* *Traverse* foregoing; and the Ship will be found at the Point T.

4. Draw T R, the Meridian of the Ship, parallel to the Meridian of the *Lizard* L D, till it meet with the Parallel of Lat. of *Madera* S M, in R. and draw T M; so shall T R. be the $\times$ Latitude or Southing, R M the Departure or Easting, and T M the Distance the Ship hath to make to *Madera*.

Solution.

Courses	D.	P. $\times$ lat. S	Lat. in	D. W.	$\times$ lon	long. in
S. S. W.	70	2 64. 7	46 $^{\circ}$ 41'	26.8	40.0	7 $^{\circ}$ 23'
S. W. b. W.	80	5 44. 4	44:28	66.5	94.0	12 : 05
W. b. S.	90	7 17. 6	43:55	88.3	124.0	18 : 17
W. S. W.	100	6 38. 3	41:49	92.4	125.0	24 : 32
						383:0 $\times$ Lo. L.
		$\times$ Lat.	165. 0	Depr.	274.0	Leagues

I shall omit the Investigations of the several Differences or Longitude in the Table above, for brevity sake, and leave them to the diligent Learner. The $\times$ Latitude is 165 Leagues, and the Depr. 274 Leagues the Ship hath made; therefore by the sixth Case of *Plain-Sailing*, Meth. 1. The Course will be found S. $59^{\circ} 00'$ W. and the Dist. 320 Leagues, Latitude the Ship is in' $41^{\circ} 40' N^{\circ}$. and Longitude $24^{\circ} 32' W$. The $\times$ Latitude in meridional Parts between $49^{\circ} 55'$ Latitude is 237 Leagues, which set from L to P, and draw N P. (which is the whole $\times$ Longitude the Ship hath made = 383 Leagues) parallel to T V, till it meet L T, produc'd in N. Again, the meridional $\times$ Lat. between $41^{\circ} 40'$ Lat. in, and *Madera's* Lat. $32. 25.$ is 232 Leagues, which set off from T to m, and draw the $\times$ Longitude to *Madera's*, n, as before directed; so have you finished the Scheme

Scheme or Projection. Lastly, To find the Course (Bearings) Distance, and Easting, the Ship must make to her intended Port *Madera*, by Case 1. *Mercator's Sailing* foregoing: Thus,

M. P.

Lat. {	Ship 41 : 40	} 2755	{	Lon. {	24 : 32	W.
	Maid. 32 : 25					17 : 42
		9 : 15		697		6 : 50 E.
		20		3)		20
				232 Lgs.		
N. Lat. 185		Lgs. M.	N. Lat.	137	Lgs. N. Long.	

Then say,

As Mer. N. Lat. .. R :: N Long. .. T. Course.
 — 232 Lgs. — T. 45. — 137 Lgs. — S. 30° 34' E.

As S. C. C. .. N. Lat. :: R .. Dist.
 — S. 59°. 26'. — 185 — S. 90 — 215 Leagues.

As S. C. C. .. N. Lat. :: S. C. .. Depr.
 — S. 59°. 26'. — 185 — S. 30° 34'. — 202 Lgs. E.
 Ergo, *Madera* bears from the *Lizard* S. 270. : 38'.
 W. or near S. S. W. $\frac{1}{2}$ W. Dist. 395 Leagues; We-
 sting or Departure 184 Leagues.

The *Lizard* bears from the Ship No. 580. 57. E. or
 Near N. E. by E. $\frac{1}{4}$ E. Dist. 39 Leagues; Departure
 274 Leagues E.

Madera bears from the Ship S. 30°. 34'. E. Dist. 215
 Lgs. Easting to *Madera* 109 Lgs. *Facit.*

Parallel Sailing.

Parallel Sailing is a Branch of *Mercator's Sailing*, it is
 of Use in Sailing East or West, or in the same Paral-
 lel of Lat. It's manifest from the Scheme in Page 27, that
 the Meridians incline from the Equinoctial nearer and
 nearer, till they Meet or Intersect in the Poles of the
 World N. and S. and consequently the Degrees of Lon-
 gitude grow less and less, the nearer you approach the
 Pole.

Pole. See the Scheme p. 27. in which P represents the Pole, P S E a Quadrant of the Meridian, Q E the Semidiameter of the Equator, and A S the Semidiameter of any Parallel of Latitude, which is to be the Semidiameter of the Equator, as the Sine of the Arch P E, to the Sine of the Arch P S; that is, as the Radius is to the Sine-Complement of the Latitude.

Again, since the Circumferences of all Circles are as their Radius's directly, and that like Parts have the same Proportion with their Whole; it follows, that the Breadth of a Degree of Longitude in any Parallel of Latitude is to the Breadth of a Degree in the Equator, as the Sine-Comp. of that Lat. to the Radius; and consequently as the Miles in the one to the Miles in the other.

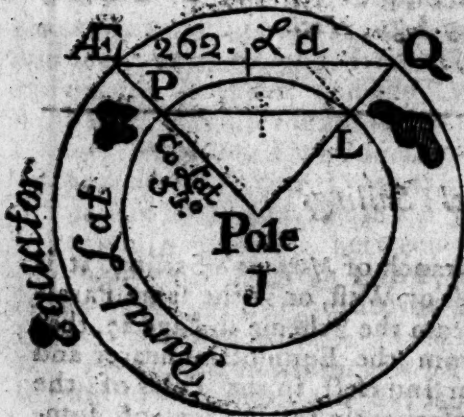
Prob. 14. Case I.

Exam. 1. Given 2. Longitude between two Places in the same Parallel or Latitude, required their Distances. What is the Distance between Cape St. Vincent and St. Mary's?

Preparations

Profr	23 : 40 W.	} Lon	{	St. Mary	} Lat. 37° N
Subtr	15 : 35 W.			C. St. Vinc.	
	13 : 05	= 78m. or 262 Lgs. the 2. Longit.			

Explanations



The outward Circle represents the Equator, the inward the Parallel of Lat. of 37°. P the Pole, P E = P Q Meridians (of S. Mary's and St. Vincent) meeting in the Pole of the World. EQ. the 2. Long. and P L the Dist. between St. Mary's and C. St. Vincent, E P. the Lat. of P the Comp. Lat. of both Places.

End.

Construction 1. With a Sine of 90° (= Chord of 60°) describe the Circle, AEQ .

2. With the Sine of the Comp. Lat. 60° , on the same Center p describe the Parallel of Lat. PL .

3. Draw the Lines pAE for the Meridian of *St. Mary's*, and set off the * Longitude 262 Lgs. from AE to Q , and from the Point Q for the Meridian of *Cape St. Vincent*; so shall L be *St. Vincent*, and P *St. Mary's*.

Lastly, Draw PL , and it's the Dist. required; and being measured on the same Scale of equal Parts, you took the * Longitude AEQ from, gives 210 Leagues.

Demonst. The Triangles, pAEQ and pPL , are similar and proportional by the parallel Lines AEQ and PL , or by the equal Angles in each; therefore by *Euclid. Lib. 6. Prop. 4.*

1. As $\text{pAE} \dots \text{AEQ} :: \text{pP} \dots \text{PL}$
i.e. ... $\text{S. } 90^\circ \dots \text{* Long.} \dots \text{S. C. Lat.} \dots \text{Dist.}$
2. As $\text{pP} \dots \text{PL} :: \text{pAE} \dots \text{AEQ}$
i.e. $\text{S. C. Lat.} \dots \text{Dist.} :: \text{S. } 90^\circ \dots \text{* Long.}$
3. As $\text{AEQ} \dots \text{AEp} :: \text{PL} \dots \text{pP}$
i.e. As * Long. ... $\text{S. } 90^\circ \dots \text{Dist.} \dots \text{S. C. Lat. } 60^\circ$

Therefore Solution Logarithmic.

As $\text{S. } 90^\circ \dots \text{* Long.} :: \text{S. C. Lat.} \dots \text{Dist.}$
— $\text{S. } 90^\circ$ — 262 Lgs. — $\text{S. } 53^\circ$ — 210 Leagues.

Instrumental by Gunter's Scale.

Observe in this and the following Cases the general Rule, p. 87, 88. Case 4. *Mercat. Sailing.*

This Case may be wrought by the Pen in all the Methods exhibited in *Plain Sailing*, Case 1. assuming the Comp. Lat. (the Course) and * Long. the Distance, to find the Departure, which will be equal here to the Distance in the Parallel.

Case 1. Exam. Two Ships 100 Leagues distant on the Equator; they both sail No. alike Dist. till they come into the Lat. of 60° North. What is their Distance asunder in that Latitude?

Here is the same Data, as before, A. s. * Longitude 100 Leagues, and parallel Latitude 60° . therefore project and work as before, viz.

As $\text{S. } 90^\circ \dots \text{S. C. Lat.} \dots \text{Dist.}$
— $\text{S. } 90^\circ$ — 100 l. — 30° — 50 Leagues.

Here you see the gross Error of the *Plain Sailing*, in which the Ships will be as far asunder in this Latitude, or even the Pole it self as on the Equator; whereas you see by this Sailing, they are but half the Distance asunder, and in the Latitude of 800. they are but one tenth of the Distance asunder, *viz.* in this Case but 10 Leagues, and if (possible) they sail to the North Pole, they must necessarily meet.

Corollary. Hence also is found how many Miles make a Degree of Longitude in any (Parallel of) Latitude; by which the Table following after the meridional Parts was made.

Case 1. Examp^t 34. If on the Equator 60 Miles makes a Degree of Longitude, how many Miles makes a Degree of Longitude in the Latitude of 50?

As Equin. Deg. :: S. C. Lat. ... Paral. Deg.
— S. 90. — 60m. — 400. — 38,57 Miles.

By the Plain Scale, Thus;

The given Latitude (as here) 500. taken from the Line of Chords, and laid on the Line M. L. (Miles of Longitude) will give the Miles of a Degree of Longitude in that Latitude, in this Case 38, 57. as before.

Now if you would turn Miles of Easting or Westing into Degrees of Longitude, it's done by this Proportion; *Table 15.* As the tabular Miles, for the Latitude you sail in to 1°; so is the Miles you sailed to the Degrees of Longitude; thus,

Suppose you sail 150 Miles in the Latitude of 60: the tabular Miles is 30. Then,

As 30m. ... 1° :: 150m. ... 5° = 100 Lgs. and contrary; to convert Degrees of Longitude into Miles of Easting or Westing. Say,

As 1° ... 30m. :: Long: ... 30m. P. M. ... 150m. Easting or Westing.

By the Help of this Table, may all the Cases in this Sailing be resolved, which I leave to exercise the Ingenuity of the young Student.

Prob. 15. Case 2. Given, two Places in one Line and their Distance; required their Longitude. Suppose a Ship sails West 210 Leagues from Cape St. Vincent, What Longitude is she come into?

This

This is only the first Case inverted ; therefore having described the Equator with a Sign of 90° , and the Parallel of Latitude of C. St. Vincent, with the Sine of its Comp. 53° , also drawn the Meridian $p Q$. Set off 210 Leagues from L to P, and draw the Meridian $p \bar{A}$ the Dist. Line L P and the $\propto$. Long. Q $\bar{A}$, which measur'd on the equal Parts, is = 262 Leagues,

Logarithmic.

As S. C. Lat. $\propto$ Dist. $\therefore R \propto \propto$ Long.
 — S. 53° — 210 — S. 90° — 262 Lgs.

To Long. Cape St. Vincent — 10 : 35 W,
 Add $\propto$. Long. 262 Leagues or — 13 : 05 W,

Sum is the Longitude the Ship is in = 23 : 40 W,

This Case may be also work'd by the Pen, in all the various Methods of Plain-Sailing by Case 3. supposing the Course there as the Comp. Lat. here, the Departure there as the Distance in the Parallel here ; and the Distance found there shall be equal to the $\propto$. Longitude here.

Case. 2. Exam. 2. Two Islands (or Head-Lands) are in the Latitude of $70^{\circ} 10'$ N°. Dist. asunder 250 Leagues ; the Eastmost Island is in Long. of $15^{\circ} 30'$ W. What Long. is the Westmost Island in ? Project, and Work as before directed, saying,

Then to the Long. of the Eastern Isle 15 : 30 W,
 Add the $\propto$. Longitude — 36 : 17 W,

Sum is the Long. of the Western Isle 51 : 47 W

Case 2. Exam. 3. Two Ships are in one Latitude of 40° N°. Dist. asunder 300 Leagues ; they both sail South the same Distance, till they come under the Equinoctial ; I demand their Distance asunder there ? and if the easternmost Ship, be in the Long. of $20^{\circ} 15'$ W. the Sun being on her Meridian. What Longitude and Hour of the Day hath the westernmost Ship ?

The α . Longitude or Distance between the Ships on the Equator, is 39 $\frac{1}{2}$ Leagues, or 19° 36' found as in the last Example.

Then to the Longitude ————— 20 : 15 W.

Add α . Longitude ————— 19 : 36 W.

Longitude Western Ship ————— 39 : 51 W.

Now since Longitude and Time are both reckoned on the Equinoctial, and that every 15° of the Sun's Diurnal Motion in the Heavens is equal to one Hour of Time on Earth; therefore divide the α . Longitude between the Ships by 15, (as below) and the Quote gives the Difference of Time between them: Thus,

5) 19° : 36'

3) 3 : 55 : 12"

— 1 : 18 : 24'

Divide by the Ratio of 15,

i. e. 5 and 3, the Quote is 1

Hour, 18 Min. 24 seconds of

Time; which subtr. from 12

Hours, remains 10h. 41' 36" the

Hour of the Day by the Westernmost Ship, when it is Noon by the Easternmost.

Prob. 16: Case. 3. Given α . Longitude and Distance of two Places in the same Lat. required the Lat. Suppose two Islands are distant asunder 210 Leagues E. and W. and the α . Longitude between them is 26 $\frac{1}{2}$ Leagues; I demand what Latitude they are in?

For the Projection, see the Scheme to the first Case of this Sailing; wherein, having described the Equator with a Sine of 90° set off the α . Longitude 26 $\frac{1}{2}$ Leagues, and draw the Meridians of the Islands $p \ A \ E$ and $p \ Q$.

2. Set off the Distance 210 Leagues or = Parts from $A \ E$ to d , and from the Point d draw $d \ L$ parallel to the Meridian $p \ A \ E$, to cut the other Meridian $p \ Q$ in L .

Lastly, with the Dist. $p \ L$, one Foot in p , sweep the Parallel of Latitude, and draw the Distance $P \ L$, which shall be equal to $A \ E$, and $p \ P = p \ L$, the Comp. of the Latitude required which is measur'd on the Line of Sines.

Logarithmically.

As $\propto$. Long. .. R :: Dist. .. S. C. Lat.
 — 262 Lgs. — S. 90° — 210 Lgs — 53° which
 subtr. from 90 , gives the Lat. of the Islands 37° N $^\circ$, if
 they are situated in the Northern Hemisphere.

Case 9. Exam. 2. Two Ships on the Equator, 400 Miles
 from one another, both sail directly North alike Dist. till they
 are 150 Miles asunder; what Latitude are they in?

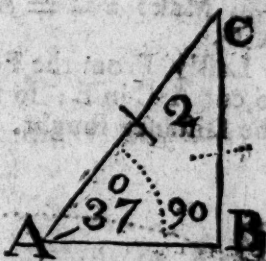
By the Logarithms,

As $\propto$. Long. .. R :: Dist. S. C. Lat.
 — 400m — S. 90° — 150m — $67^\circ 59'$ requir'd.

There are other Varieties in this Sailing; as of two
 or more Ships, or Places in different Latitudes, which I
 forbear to mention, because these are sufficient for the
 Navigator's Use; however for the sake of the Curious,
 I shall exhibit Variety of Projections in Parallel-Sailing be-
 sides the foregoing.

Exam. Let the Parallel Lat.
 be 37° N $^\circ$. and the $\propto$. Long. 262
 Leagues, as in the first Case of
 this Sailing,

Projection 2. By Plain Tri-
 angle with the Comp. Lat. 53°
 and $\propto$. Long. 262 Leagues, pro-
 ject the Triangle A B C as di-
 rected in Case 1. Meth. 1. of Plain-Sailing; so shall
 the Perpendicular B C, be the Distance in the Parallel
 requir'd.

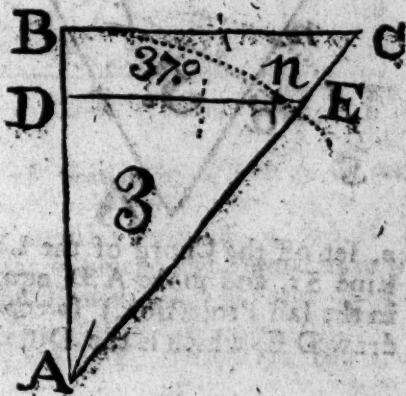


Projection.

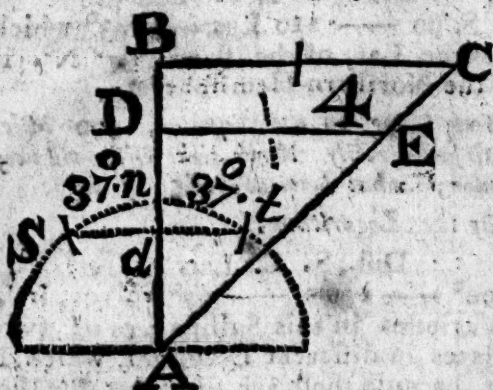
1. Make A B = Chord
 60° and erect the Per-
 pendicular B C equal to
 the $\propto$. Longitude, and
 draw C A.

2. Set the Latitude
 37° on the Arch of 60°
 from B to $\propto$.

3. From the Point $\propto$
 draw D E Parallel to the
 $\propto$. Long. B C, to cut
 A C in E, so shall D E
 be the Distance required.



Projection 4.



1. Make $A n$ = Chord of 60° and $n B$ = the Double thereof.

2. Erect the Perpend. $B C$ which make = the x . Longitude (262) (as $B C$) and draw the Line $C A$.

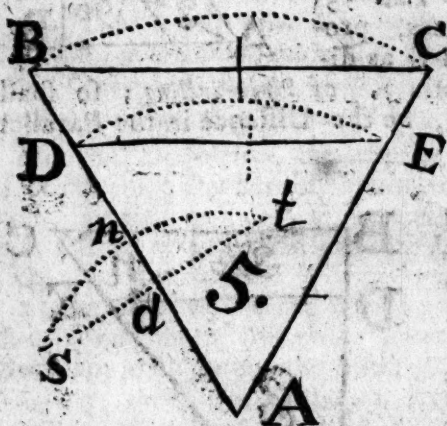
3. Set off the Chord of the Lat.

37° upon the Arch, or sweep off 60° both Ways from n to S and t , and draw the Chord Line $S t$, to cut the Line $A B$ in d .

4. Make $d D = A d$. or $A D =$ the Double of $A d$.

Lastly, From the Point D draw a Line Parallel to $B C$ to cut $A C$ in E ; so shall the said Line $D E$ be equal to the Distance sought.

Projection 5.

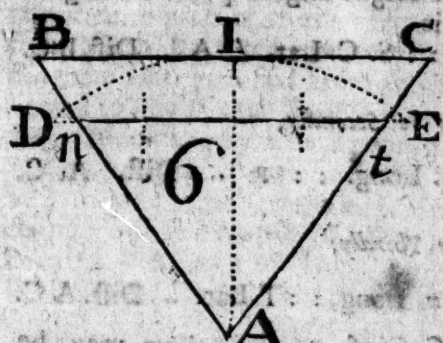


1. Draw the Line $A B$, and make $A n$ = Chord of 60° and $A B =$ double thereof, sweep the Arch $B C$; which make equal to the x . Longitude 262, and draw the Line $B C$ and $C A$.

2. Describe the Arch of 60° and on it both Ways from

n , set off the Chord of the Lat. 37° and draw the Chord Line $S t$, and make $A D$ equal to the double of $A d$ (as in the last Projection,) sweep an Arch from D to E , and draw $D E$, which is the Distance required.

Projection 6.



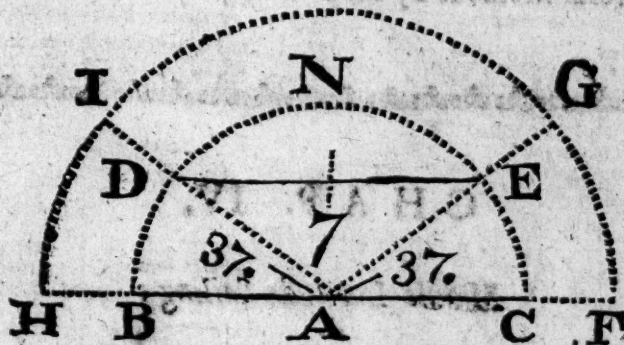
1. Draw the Line A I, equal to the Chord of 60° and describe the Arch D'I'E, and make the Arch I D and I E each equal to the Chord of the Latitude 30° and on the Point I, erect a Perpendicular to A I.

2. Set off half the π . Long. 131 Leagues = Parts both Ways from I to B and C, and draw the Lines B A and C A.

Lastly, Draw the Chord Line D E, so shall π be the Dist. sought.

Projection 7.

1. Make the Angles G A F and H A I = 37° .



and draw the Lines of Radius's A F = A G, = A H = A I.

2. On the Center or angular Point A, with half the π . Long = 131 Lgs. = Parts. Sweep the Semi-circle B N C, which cuts the former Radius's A G and A I in the Points D and E.

Lastly, draw the Line D E, which is the Dist. required.

We may also vary the Proportions in the second Projection, as is obvious to those that work, by making each Side the Radius in a Right-angled plain Triangle: As for Instance, where it is

1. As $R \dots x$. Long. $A C :: S. C. Lat. \angle A \dots$ Dist. $B C$.

It may be Secondly,

As Sec. Lat. $\angle C \dots x$. Long. $:: R \dots$ Dist. A, C .

Or Thirdly,

As Sec. C. Lat. $\angle A \dots x$. Long. $:: T. Lat. \dots$ Dist. $A C$.

To conclude, the 2d Case of *Parallel-Sailing*, may be wrought by the Pen in all the Methods by Case 2. of *Plain-Sailing*; by taking the Lat. for the Angle of the Course, and the Dist. in the Parallel for the x . Lat. and then the Dist. in *Plain-Sailing* will be equal to the x . Long. required here.

Also in the third Case of *Parallel-Sailing*, taking the x . Long. and Dist. in the Parallel, for the Dist. and x . Lat. to find the Course; which here is the Parallel Lat. It may be solv'd by Case 4. *Plain-Sailing*, according to the several Methods by the Pen only.

CHAP. IV.

Middle Latitude Sailing :

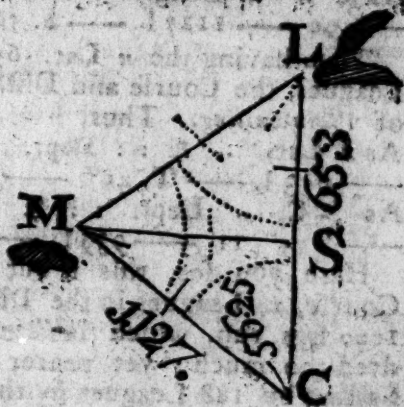
OR a Method of Sailing nearly agreeing with *Mercator's*, performed without a Table of meridional Parts (and may be wrought by the Logarithms, *Gunter's* Scale, or any of our Methods by the Pen in *Plain-Sailing*.) Some ingenious Artifts have observed, that this Sailing will serve without any considerable Error, in Runnings of 450 Miles, between the Equator and the parallel Lat. of 30 Degrees; of 300 Miles, between 30 and 60 Degrees, and of 150 Miles, as far as we have any Occasion; therefore sufficiently exact to find the x . Long. in any

any 24 Hours run; and whoever was the first Author of this Sailing, he ought to be had in Esteem for the Contrivance, which is thus: Having first taken an arithmetical Mean between the two Latitudes; that is, by adding the Lat. you sail from to the Lat. you are in (or are bound to) half that Sum shall be the Mean or *Midd. Latitude*; then say, by this Theorem or Proportion; As the S. Comp. Middle Lat. is to the Dep., (or Miles E. and W.) so is $\angle$ S. 90° to the $\angle$ Long. required. Now if you change but the Name of S. Comp. Midd. Lat. to S. C. Parallel Lat. and of Dep. to Miles, of Dist. East or West in a Parallel, the Proportion is the same with the second Case of *Parallel-sailing* foregoing. There are other Proportions in this Sailing, which we will shew a little farther.

I shall here propose the same Question, as I did in the first Case of *Mercator's* or *Wright's Sailing*, viz.

Case 1.

I demand the Course, Distance, and Departure (or Westing) from the Lizard to Antegoa?



Preparation.

Lizard, } $\begin{cases} 49^\circ : 55' \text{ N}^\circ. \\ 17 : 15 \text{ N}^\circ. \end{cases}$ } Long. } $\begin{cases} 5^\circ : 23' \text{ W.} \\ 61 : 44 \text{ W.} \end{cases}$

Sum 67 : 10

$\angle$ Long. 56 : 31

Sum or M. Lat. 33 : 35
90 : 00

or = 1127 Lgs.

Comp. Mid. Lat. 56 : 25

Difference = 32 : 40 = 653 Lgs. $\angle$ Lat.

Projection. 1. Draw C L for a Meridian, or North and South Line; then as in the first Case of *Plain-Sailing*, with the Comp. Midd. Lat. $56^{\circ} 52'$ (as Course,) and $\times$. Long. 1127 Lgs. (as Dist.) project the Triangle C S M.

2. C. S. being continued, make S L equal to the $\times$. Lat. 653 Leagues, and draw L M the Rhumb-Line or Dist. So shall L represent the *Lizard*, M. *Madera*, the Angle S L M the Course, L M the Dist. and S M the Westing from the *Lizard* to *Antegoa*; all which may be measured by the Chords and equal Parts, as I have sufficiently exhibited in the foregoing Problems, to find which *Logarithmic*, in Triangle C S M, $\angle$ C. and C M to find S M. the Departure, as in Case 1. Meth. 1 *Plain-Sailing*.

As $\times$. Long. :: S. C. Midd. Lat. :: Depr.
— S 90° — 1127 l. — S. $56^{\circ} 25'$ — 939 Lgs.

Then having the $\times$ Lat. 653 Lgs. and the Depr. 939 Leagues, the Course and Dist. may be found by Case 6. of *Plain-Sailing*. Thus,

As $\times$. Lat. :: $\times$. Depr. :: T. C.
— 653 l. — T. 45° — 939 l. — S. $55^{\circ} 11'$ W.
As S. C. :: Depr. :: $\times$. Dist.
— S $55^{\circ} 11'$ — 939 l. — S. 90° — 1144 Lgs.

Here you see, this is but 43' more Westerly in the Course, 20 Leagues in the Dist. 25 in the Depr. in above 1000 Lgs. run, which is about two Leagues in a Hundred too much; yet nearer to *Mercator's* or the true Sailing by 188 Leagues in the Westing, and 59 Leagues in the Distance run (of this Voyage, which is so much Westerly) than *Plain-Sailing*; but when your Course is more Southerly, as in a Voyage from the *Lizard* to *Port a Port*, *Lisbon*, *Cadix*, the *Streights Mouth*, *Canary*, or *Cape de Verd* Islands; the Diff. between this Method and the *Mercatorian* will be very small; and therefore much safer to trust to, than *Plain-Sailing*.

The working the Proportions by *Gunter's Scale* in this Sailing will be found very easy to the Learner, if he observes the general Rule in Page 87, 88, Case 4. *Mercat. Sailing*.

Likewise this Case may be solved by the Pen only, in all the Methods propos'd; as in Case 1st and 6th of *Plain-Sailing*; *Arithmetical* foregoing.

Middle Latitude Sailing.

109

Case 2. Given Latitudes and Course; required Distance, Departure, and $\times$ Longitude.

Sailing from the Lat. $48^{\circ} : 50'$ N. and Long. $7^{\circ} : 30'$ W. S. W. by W. until by Observation the Ship is in Lat. $47^{\circ} : 10'$: N. What is the Distance run Westing and Long. arrived in?

Preparation.

$48^{\circ} : 50'$ Dep.

$47 : 10$ Observat.

$1 : 40 = 100m. \times$ of

$48 : \frac{1}{2}$ Sum, or middle

$7^{\circ} : 10'$ W.

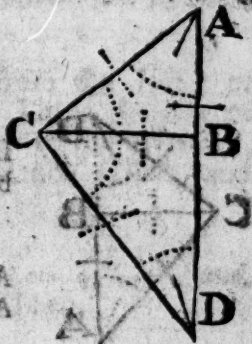
$3 : 44$ W. $\times$.

$10 : 54$ W.

Long.

Projection 1. by Case 2. Plain-Sailing, construct the Triangle A B C; with the Course S $56^{\circ} : 15'$ W and $\times$ Lat. $100m.$ given.

2. make the Angle B C D, equal to the middle Lat, $48^{\circ} : 10'$, and draw the Line C D till it meet with the $\times$ Lat. A B produc'd in D. So shall D C be the $\times$ Long. and the Angle B C D, the S. Comp. of the middle Lat.



Operation. by Logarith. the same as in Case 2, of Plain-Sailing.

As S. C. C. $\times$ Lat. $100m.$: : Dist. run
S $33^{\circ} : 45'$: $100m.$: : S. 90 : 178 Miles.

As S. C. C. $\times$ Lat. $100m.$: : S. C. : : Dep. West.

S. $33^{\circ} : 45'$: 100 S. $56^{\circ} : 15'$: 150 Miles.

Then find $\times$ Long. as in Case 3. of Plain-Sailing. You found the Distance, i. e.

As

As S. C. mid. Lat. .. Dep. :: R. π . Long. West.
 $\text{---} S. 42^{\circ} : 300' \text{---} 150m. \text{---} S. 90^{\circ} \text{---} 324 \text{ Miles}$
 Exactly agreeing with Case 2. *Mercator Sailing.*

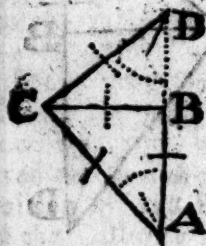
Case 3. *Given Lat. and Dist. required Course, Departure and π . Longitude.*

Sailing North-westward from Cape St. Vincent in Portugal, 300 Miles, until by Observation the Ship is found in the Latitude of $41^{\circ} : 00'$ N. What's the Course steer'd, Departure, and Longitude the Ship is in?

Preparation.

$41^{\circ} : 00'$ — Observ'd	} Lat. {	$4^{\circ} : 15'$ W.	} Long.
$37 : 15$ C. St. Vincent's		$10^{\circ} : 35'$ W.	
$\text{---} 3. 45 = 225 \text{ diff. of}$		$\text{---} 14 : 50 \text{ W.}$	
$39 : 07 = \frac{1}{2} \text{ Sum or mid.}$			

Construction.



1. With the Dist. 300m. and π . Lat. 22m. make the Triangle ABC by Case 4. *Plain-sailing*, continuing

2. Make, (as in the last Case) the Angle DCB = middle Lat. $39^{\circ} : 7'$ And draw CD for the π . Long.

Logarithmetical, by the 3d and 4th Case of *Plain-sailing*.

As Dist. R. :: π . Lat. .. S. C. Course.
 $\text{---} 300m. S. 90^{\circ} \text{---} 225m. S. 48^{\circ} : 35' \text{ C. N. } 41^{\circ} 25' \text{ W.}$

As R. :: Dist. :: S. C. Departure
 $\text{---} S. 90^{\circ} \text{---} 300m. \text{---} S. 41^{\circ} : 52' \text{---} 198m. \text{ West.}$

As S. C. mid. Lat. .. Dep. :: R. .. π . Long. W.
 $\text{---} S. 50^{\circ} 53' \text{---} 198 \text{---} S. 90^{\circ} \text{---} 255 \text{ Miles.}$

Or thus, by Prop. 1. of Opposite Sides and Angles, in Page 28, Rule of Sines.

As $S. \angle D$.. Side AC :: $S. \angle A$.. Side DC i.e.
As $S. C$ mid. Lat. .. Dist. :: $S. Course$.. $\times$ Long.
———— $S. 50^\circ : 53'$ ——— 300° ——— $41 : 25' 255$ mi

Or,

As $T.C$ mid. Lat. .. Dep. :: $S.C$ mid. Lat. .. $\times$ Long.
———— $T. - 50^\circ : 53'$ ——— 198 ——— $Sec. 50^\circ : 53'$ ——— 255 mi

Note. The foregoing Case 2. may be work'd by the Pen, by all the Methods; as in Case 2. *Plain-Sailing*. And this 3d, by the 4th and 3d of *Plain-Sailing* Arithmetical. $\times$ Long. here is $= 4^\circ : 15'$ W. which added to the Departed Long. gives present Longitude.

Case 4. Given Latitude and Depart. required Course, Dist. and $\times$ Long.

Sailing between the N. and E. from the Lat. of $45^\circ : 00'$ N. and Long. $15^\circ : 50'$ till I'm in the Lat. of $40^\circ : 49'$ N. per Observation, fifty Miles to the eastward. I demand the Course steer'd, Distance sail'd, and Longitude come into?

Prop. The $\times$ Lat. is 89th. and middle Lat. $45^\circ 44'$ found, as in the three last Cases. Then,

Projection.

1. With the $\times$ Lat. 89m. and Dep. 59m. Project the Triangle ABC by the 6th Case of *Plain-Sailing*.



2. Make the Angle $BCD =$ middle Lat $45^\circ : 44'$ and draw CD for the $\times$ Long. as before.

Opera-

Operation by Log. as in Cases 6th and 3d of Plain Sailing, Meth. i.

As $\times$ Lat. $R ::$ Departure T . Course
 — 98m. — $T. 45^\circ$ — 59m. — No. 31d : 5' East.

As S. C. $..$ Dep. : R — Dist.
 — $31^\circ : 5'$ — 59 — S. 90. — 114 Miles.

As S. C. mid. Lat. $..$ Dep. : R $\times$ Long.
 — S. $44^\circ : 16'$ — 59m. S. 90 — 84m. or $1^\circ : 14'$ E.
 Then Long. $14^\circ 30'$ — $\times$ Long. $1^\circ : 24'$ E. — $13^\circ 26'$ W.
 the Long. the Ship is in.

To find the $\times$ Long. (for any 24 hours run) by the Traverse-Tables. Having found the Comp. of the middle Lat. for the two Latitudes, (suppose of Yesterday and to Day) which let be as in the following.

Examp. S. C. middle, $44^\circ : 16'$ but 44° is the nearest whole Degree, which is near enough; and Departure 59m. to find the $\times$ Long.

Practice. Find the Comp. middle Lat. (44°) amongst the Degrees, at the Top or Bottom of the Table, and under it, if you find it at Top, or above it, if you find it at Bottom) in the Column of Departure; find your Departure, and right against it, in the Right-hand Column (of $\times$ Long.) is the $\times$ Long. If you cannot find the Departure in the Column exactly agree with yours, break it into two Parts, and take out for both these Parts, at twice, under the same Degrees, and the Sum of the two $\times$ Longs. found will be the $\times$ Long. sought.

Examp. Let the Comp. middle Lat. and Departure be as above; and find 38, 2 (— 59 = to) 20, 8, in the Column of Departure; against which (in the Column of $\times$ Long.) stands 55, and 30, which added together makes 85m. for the $\times$ of Long. sought.

This 4th Case of middle Lat. may also be wrought by the Pen, in all the Methods, by Case 6th and 3d of Plain-Sailing Arithmetical.

These four Cases are all that are useful in the Practice of keeping a Reckoning at Sea. As for the other Cases which are less useful, I shall only insert the *Data* and *Quæsitæ*, with the Canons or Proportions for finding what is requir'd, and leave the Operations for the Learner's Practice.

Case 5. Given one Lat. Course and Dist. requir'd the other
Lat. Dep. and $\times$ Long.

1. For the $\times$ Lat.

As R .. Dist. :: S. C. C. .. $\times$ Lat.

2. For the Departure.

As R .. Dist. :: S. C. .. Departure.

3. For the $\times$ Long.

As S. C. midd. Lat. .. Dep. :: R .. $\times$ Long.

Case 6. One Lat. Course and Dep. given. Other Lat. Dist.
and $\times$ Long. requir'd.

1. For the $\times$ Lat.

As S. C. .. Dep. :: S. C. C. .. $\times$ Lat.

2. For the Dist.

As S. C. Dep. :: R .. Dist.

3. For the $\times$ Long.

As S. C. midd. Lat. .. Dep. :: R .. $\times$ Long.

Case 7. Given one Lat. Dist. and Dep. Required other
Lat. Course, and $\times$ Long.

1. For the Course.

As Dist. .. R :: Dep. .. S. Course.

2. For the $\times$ Lat.

As S. C. .. Dep. :: S. C. C. .. $\times$ Lat.

3. For $\times$ Long.

As S. C. midd. Lat. .. Dep. :: R .. $\times$ Long.

Case 8. Course, Dep. and $\times$ Long. given. Required both
Latitudes and Distance.

1. For the Distance.

As S. C. .. Dep. :: R .. Dist.

2. For the $\times$. Lat.

As S. C. .. Dep. :: S. C. C. .. $\times$. Lat.

3. For the middle Lat.

As $\times$. Long. .. R. :: Dep. .. S. C. midd. Lat.

Then add half the $\times$. Lat. to the middle Lat. (when found, as above) the Sum is the greater Lat. And subtracting the $\times$. Lat. from the middle Lat. the Remainder is the lesser Latitude required.

Case 9. Given middle Lat. and Dist. to find both Latitudes, Depart. and $\times$ Long.

1. For $\times$. Lat. and consequently both Latitudes.

As Radius to Dist. :: S. C. C. .. $\times$. Lat.
Then find both Latitudes; as in Case the 8th.

2. For the Departure.

As R. .. Dist. :: S. C. Departure.

3. For the $\times$. Longitude.

As S. C. middle Lat. .. Dep. :: R. .. $\times$. Long.

Case 10. Course, Dist. and $\times$. Long. given, to find both Latitudes, and Departure.

1. For the middle Latit.

As $\times$. Long. .. Dist. :: S. C. .. S. C. midd. Lat.

2. For $\times$. Latitude.

As R. .. Dist. :: S. C. C. .. $\times$ Lat.

Then find both Latitudes, as in Case 8th.

3. For the Departure.

As R. .. Dist. :: S. C. Departure.

Case 11. Given Course, $\times$. Lat. and $\times$. Long. to find both Latitudes, Dist. and Departure.

1. As for the middle Latitude.

As $\times$. Long. .. T. C. :: $\times$ Lat. .. S. C. midd. Lat.
By $\times$ Lat. and midd. Lat. find both Latitudes; as in Case 8th.

2. For

2. For the Distance.

As S. C. C. $\propto$ Lat. $:: R \propto$ Dist.

3. For the Departure.

As S. C. C. $\propto$ Lat. $::$ Departure.

Case 12. Middle Lat. Course, and $\propto$ Long. given, to find both Latitudes, Dist. and Departure.

1. For $\propto$ Lat.

As T. C. $\propto$ Long. $::$ S. C. midd. Lat. $\propto$ Lat.
Then find Distance and Departure, as in Case 11.

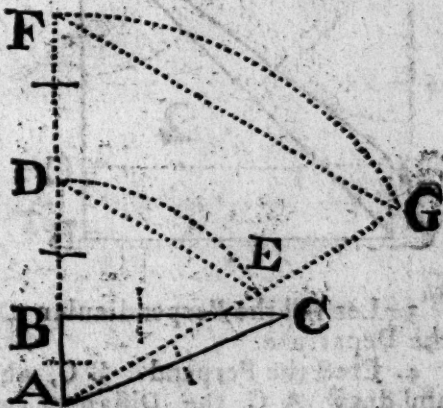
Case 13. Given one Lat. Departure, and $\propto$ Long. Required the other Lat. Course and Dist.

In this we shall give a Projection and Solution in Numbers.

Example. Suppose a Ship sails between the North and East, from the Lat. of $48^{\circ} : 50'$ North, until her Easting be 150m. and she hath differ'd her Long. 224m. What Course hath she steer'd, and how far; and what Lat. is she arriv'd in?

Projection.

1. Make $AF =$ the $\propto$ Long. 224m. $AD =$ the Dep. 150m.
2. Make AG and FG , each $=$ the Sine of 90° and draw from the Point D , DE parallel to FG , then shall AE be the Sine Comp. Lat. the Ship is in.
3. Make AB equal to the Lat. given; and this found, and BC , the Dep. required, equal to AD ; and draw AC , and it's the Dist. run required.



2. Logarithmically.

As $\times$ Lo. AF $:: R :: FG ::$ Dep. AD $:: S. Co. L. AE.$
 $224^m. S. 90 150 42^\circ : 03'.$

Whose Comp. to 90° is $47' : 57$, the Lat. which taken from the Lat. departed from, remains $53^m. \times$ Lat. Then by Case Plain-Sailing,

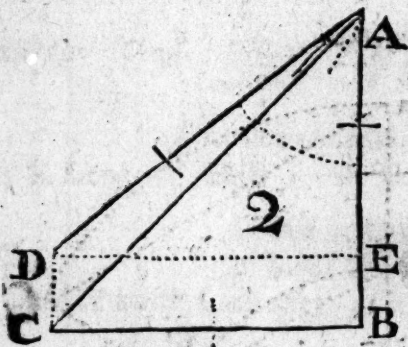
As $\times$ Lat. $:: R ::$ Dep. $:: T.$ Course.
 $53^m. T. 45^\circ 15^m. N. 70^\circ : 35' \text{ East.}$

As S. C. $::$ Dep. $:: R ::$ Dist.
 $S. 70^\circ : 35' 150^m. S 90^\circ 159^m.$

Proceed we now to shew several other Varieties of Projections in middle Lat. Sailing, to oblige the curious Learner.

For *Examp.* Let the $\times$ Lat. be 653 Lgs. the $\times$ Long. 1127 Lgs. the middle Lat. $33^\circ : 35'$, and its Complement $56^\circ : 25'$ (as in the first Case of this Sailing) to find the rest.

Projection 2.



1. Make AB = the $\times$ Lat. 653 Lgs.

2. Make the Angle DAE = S. Comp. middle Lat. $56^\circ : 25'$, and draw the Line AD, which make equal to the $\times$ Long. 1127 Lgs.

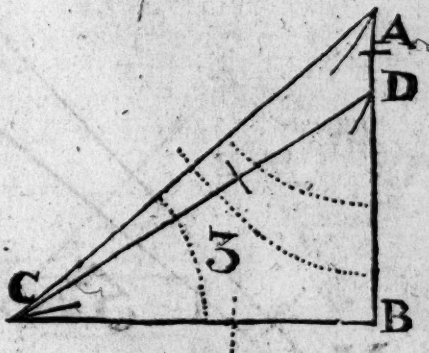
3. Let fall the Perpendicular DE, so shall DE be =, the Departure.

4. Erect the Perpend. BC, which make equal to ED, and draw AC, the Distance run, and it's done.

Projection.

1. Draw CB and make the Angle $DCB =$ the middle Lat. $33^{\circ} 35'$ and draw CD , which make $=$ the $\times$ Long. 1127 Leagues.

2. From the Point D let fall the Perpendicular DB .

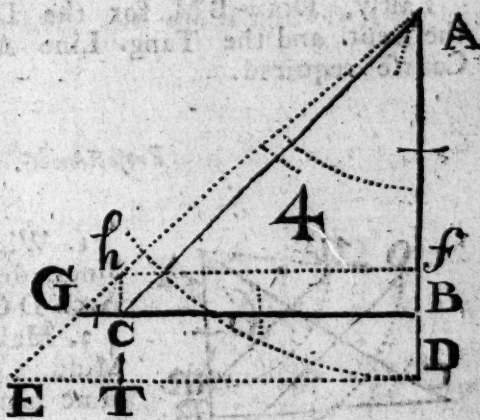


3. Produce BD and make $BA =$ the $\times$ Lat. 653 Leagues, and draw AC the Dist. so shall the Angle BAC be the Course, and BC the Departure required.

Projection 4

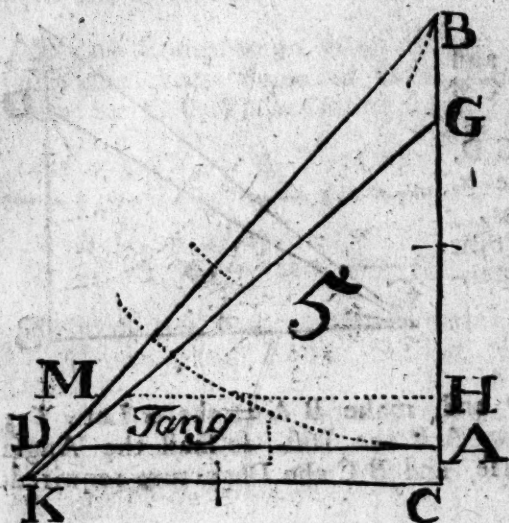
Make $AB =$ the $\times$ Lat. 653 Lgs. and erect the Perpend. BC , which make $=$ the $\times$ Longitude 1127 Lgs. and draw GA .

2. Make $AD =$ the Sine of 90° and $Af =$ the Sine Comp. of the Mid. Lat. $56^{\circ} 25'$ also erect the Perpendiculars DE and fb , cutting the Hypo. AG in h .



Lastly, Make BC equal to fb for the Departure, and draw the Dist. AC , so shall the Triangle be finished.

Projection 5.



1. Draw the Meridian OB , and from the Point A make $(AO \text{ or }) AB =$ the Sine of 90° .

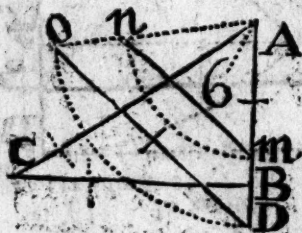
2. Make $AG =$ the Comp. of the Midd. Lat. $56^\circ 25'$ from the Sines.

3. Make BH and GC , each equal to the $\times$ Lat. 653 Lgs. erect the Perpend. AD , and draw HM and CK parallel thereto.

4. Make $CK =$ the $\times$ Long. 1127 Leagues, and draw BG to cut HM in M .

Lastly, Draw BM for the Dist. then shall AM be the Depr. and the Tang. Line AD the Angle of the Course required.

Projection 6.



1. With 90° of the Line of Sines describe from A the Arch DO equal to 1127 Lgs.

2. Make $Am =$ the S. Comp. Midd. Lat. $56^\circ 25'$ (from the same Line of Sines) and describe the Arch mn ; then draw BO , and mn , so shall mn ,

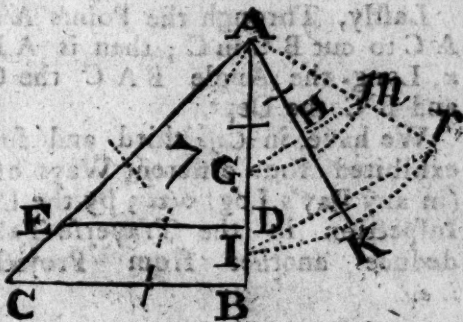
be the Westing or Departure.

3. Make $AB =$ the $\times$ Lat. 653 Leagues, and erect the Perpend. BC equal to the Westing mn , and draw AC which will be the Dist. and the Angle BAC the Course required.

Projection 7.

- I. Make A D
(upon the Meridi-
an) equal to the x .
Lat. 653 Leagues.

2. With the Comp. Midd. Lat from the Sines, sweep the Arch G H, and on it lay $\frac{1}{2}$ the x. Lat. 326 $\frac{1}{4}$ Leagues from G to H, and draw A H continued.



3. With 90° off the Sines from A describe the Arch
IK.

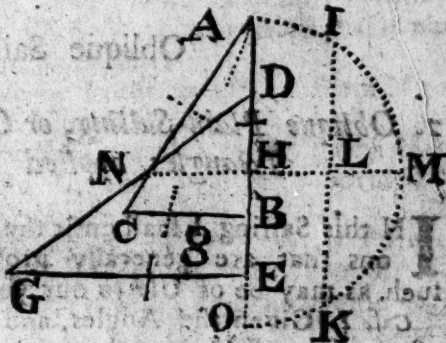
4. Lay I K twice upon the Meridian from A to B; on B erect a Perpend. B C equal to the x . Long. 1127 Leagues, and draw the Line A C.

Lastly, From D draw D E the Dept. Parallel to B C, so shall A E be the Dist. and the Angle D A E, the Course required.

Projection 8. by Semicircle.

1. With a Chord of 60° describe the Semicircle $A M O$, and cross it at right Angles with the Line $M N$.

2. Make A B equal to the x . Lat. 653
Lgs, and erect the Perpend. B C.



3. On the Semicircle AMO set off the Midd. Lat. $33^{\circ} 35'$ from M to I , and from M to K , and draw the Chord Line ILK , and set off the Distance LM from A to D , and from B to E , and on E erect the Perpend. EG equal to the $\times$. Long. 1127 Lgs. and draw GD , which cuts the Line MH produc'd in N .

Lastly, Through the Points A and N , draw the Line AC to cut BC in C ; then is AB the $\times$. Lat. EG the $\times$. Long. the Angle BAC the Course, AC the Dist. and BC the Depr.

We have, in *Case* third and fourth of this Sailing, exhibited four different Ways of finding the $\times$. Long. (in any Day's Log) viz. 3 by the Logarithms, and one by Inspection in the Traverse-Tables; we may also deduce another from Projection 4th foregoing, i. e.

As $S. C.$ Midd. Lat. $\dots \times$. Lat. $\therefore T. C. \dots \times$, Long.

Demonstration.

For, As AB . $\times$. Lat. Af $S. C.$ Midd. Lat. so is BG the $\times$. Long. $\dots DT$, which by Construction is always equal fe , the Tangent of the Course; and by *Euclid*. 6. 4.

As $AB \dots Af \therefore BG \text{ } fh (=DT)$ the Tangent of the Course.

And so by Inverting the Proportion, or Canon, any three Things being giving, the fourth may be found by *Euclid*. lib. 5. *Prop.* 14. and 16. and *Corol.* always observing to make the required Term the fourth in the Proportion.

Oblique Sailing.

2. Oblique Plain-Sailing, or Oblique Angled Plain Triangles applied to Sailing.

IN this Sailing I shall omit the several useless Questions that are generally propos'd, and insert only such as may be of Use to our young Navigator.

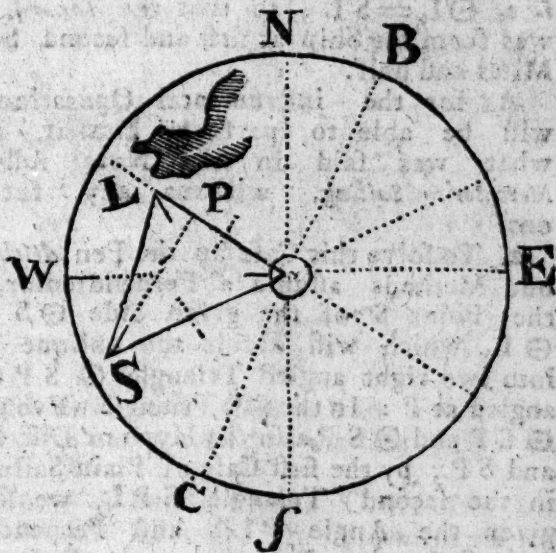
Case 1. Given the Angles, and a Side opposite to one of them, to find the other two Sides.

Exam.

Exam. Sailing along the (English) Shore W.S.W. I see a Head-Land, by the Compass (suppose the Lizard-Point) and find it to bear off my Ship, N. W. b. W. running (by the Log the same Course) 25 Miles, finds the said Head-Land to bear N. b. E. I demand how far this Head-Land was from the Ship at first and last Setting of it?

Construction.

1. With a Chord of 60 describe the Circle W N E S, and by Prob. 2. of Geom. Prob. cross it at right Angles, with the two Diameters W E and N S. So shall N represent the N^o. S. the S^o. W. the West, and the E the East.



2. Set off 5 Points from the Rhumbs or $56^{\circ} 15'$ from the Chords, from N to L, and draw $\odot L$ a N. W. by W. Line.

3. Set off 6 Rhumbs $= 67^{\circ} 30'$ on the Chords from S to S, and draw $\odot S$ the W. S. W. Line, which make equal to the Ship's Dist. run, 25 Miles.

4. Lay off 1 Rhumb or Point $= 11^{\circ} 15'$ from N to B, and draw the N. by E. Line B C.

Lastly from S draw S L parallel to B C, (by Prob. 5. Geom.) to cut $\odot L$ in L, and you have formed the Triangle $\odot S L$, in which is given the Angle $S \odot L$, viz. from the N. W. by W. to W. S. W. 5 Points $= 56^{\circ}$ and the Angle $\odot S L$ from N. by E. to E N. E. which is 5 Points $= 56^{\circ} 15'$ also; and the Angle $\odot L S$ from the S. by W. to S. by E; that is, 6 Points $= 67^{\circ} 30'$ likewise the Side $\odot S$ opposite to the Angle $\odot L S$; to

to find the Sides $\odot L$ and $S L$, which are measur'd by a Scale of equal Parts, as has been shewn. But to find them

Logarithmic. by Prop. 1. *Elem. Trigonometry* ;

As $S \angle L$.. Side $\odot S$:: $S. \angle S$.. Side $\odot L$.
 — $S. 67^{\circ} 30'$ — 25m. — $S. 56^{\circ} 15'$ — 22m. $\frac{1}{2}$.

And seeing in this Example the Angles $\odot$ and S are equal, their opposite Sides $L S$ and $\odot L$, are also equal, i. e. $\odot L = S L$; so that the *Lizard*, or Head-Land, was from the Ship at first and second Setting of it 22 Miles and half.

As for the instrumental Operation, the Learner will be able to perform himself, if he observes what was said in the Note following Case 4. *Mercator's Sailing*, without any further Instructions.

2. To solve this Case by the Pen *Arithmetically*, by all our Methods assume a Perpendicular, let fall from the Point S of the given Side $\odot S$ upon the Side $\odot L$, which will divide the oblique Triangle $\odot S L$ into two right angled Triangles $\odot S P$ and $L P S$, right angled at P : In the first Triangle we've given the Angles $\odot S P$ and $\odot S P$, also the Hypo. or Dist. $\odot S$ to find $\odot P$ and $S P$, by the first Case of Plain-Sailing *Arithmetical* ; in the second Triangle $S P L$, we shall have then given the Angle $P L S$ and Perpendicular $S P$. to find $S L$ the Distance, and $P L$, by Case 2. Plain-Sailing *Arithmetical* then $\odot P + L P = \odot L$, the Dist. of the Head-Land from the Ship.

The Use of this Case is obvious ; for as generally our Mariners judge or estimate the Distance of any Head-Land from which they take their Departure, to be so much or so much, this Case will easily solve it more true and *Mathematical*.

Case 2. Two Sides and an opposite Angle given, to find the other Angles and Sides.

A Ship in the parallel Lat. of $46^{\circ} N^{\circ}$. (as at B) describes an Head-Land (at C) distant from her 67 Miles, she sails E. S. E. 63 Miles (to D .) and then the Head-Land (at C) bears S. W. by W. from her : How did the Head-Land bear from the Ship, (when she was at B .) and how far is it distant from her, now she's at D ?

Projection

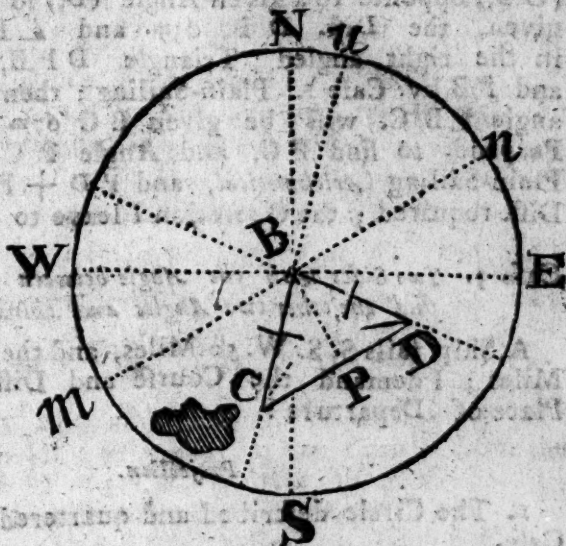
1. Describe the Circle WNE Sand quarter it as in the last Case.

2. Set off
6 P = 67°
30' from S.
and draw an
E S E Line
B D = the
Ship's Dist.
failed 63m.

3. Set off from S. towards W. 5 P = $56^{\circ} 15'$ and draw a

4. Draw from D a Line parallel to the said Line *m B* as D. C.

5. Then with 67m. = Parts in your Compasses, and one Foot in B cross the Line D C in C, and draw the Line B C, so shall C be the Head Land, and D C the Ship's Dist. from it, and the Angle B C D = Arch " n, the Bearing of the Ship from it.



I. Logarithmetical Prop. I. Trigon.

As Side B C .. S. $\angle$ D :: Side B D .. S. $\angle$ C.
 ——— 67m. ——— S. $56^{\circ} 15'$. ——— 63m. ——— S. $51^{\circ} 26'$ =
 " n. N " = N.E. by E. $56^{\circ} 15'$. — $51^{\circ} 26'$. = N " $4^{\circ} 49'$,
 or B C; that is, the Head-Land did bear from the
 Ship at first S. $4^{\circ} 49'$ W. or near S. half W. then 56°
 $15' + 51^{\circ} 26' - 180^{\circ} = 72^{\circ} 19'$ the $\angle$ B.

As S. $\angle$ D. .. Side B C :: S. $\angle$ B. .. Side D C.
 — S. $56^{\circ} 15'$ — 67m. — S. $72^{\circ} 19'$ — 77 Miles,
 the Dist. of the Head-Land from the Ship at the End of
 her Sailing.

2. Aritb-

Oblique Sailing.

Lastly, Draw the Line A C, and it's the Ship's Dist. and the Angle B A C her direct Course from her first Place, A. To find which *Logarithmically*, by Case 2. Rule of *Tangents*, *Elem. P. Trigon.*

Preparation.

$\frac{1}{3}$ $\underline{AC} + AB = Z \ 114^\circ \ 2'$ $\angle B - Z \ 3^\circ \ 18'$ is
 $\times \ 14 \ 5$ $78^\circ \ 45'$ its $\frac{1}{2} = 39^\circ \ 22'$ the
 half Sum of the unknown Angles A and C.

Logarithmic.

$\frac{1}{3}$ As $\underline{AC} \pm AB \dots \underline{AC} - AB :: T_{\frac{1}{2}} Z \text{un. } \angle :: T_{\frac{1}{2}} \angle :: \angle$
 $\frac{1}{3}$ $\frac{114m.}{114m.} \dots \frac{14m.}{14m.} - T_{39^\circ : 22'} \dots T_{5^\circ : 45'}$

Then $39^\circ : 22' \pm 5^\circ : 45' = \left\{ \begin{array}{l} 45^\circ : 07' \text{ } \left. \begin{array}{l} \text{grt. } \angle \\ \text{left. } \angle \end{array} \right\} \begin{array}{l} A. \\ C. \end{array} \end{array} \right.$

To the $\angle A \ 45^\circ : 07'$ add $\text{Sn. S. S. W.} = 22^\circ : 30'$, the Sum is $SC = 67^\circ : 37'$; that is, the Course from the Place. A is S. $67^\circ : 37'$ W. or near W. S. W.

The Dist. A C is found as in Case 1. viz.

As $S \angle A \dots \text{Side } BC :: S \angle B \dots \text{Side } AC$.

$S. 45^\circ : 07' : 64m. \left\{ \begin{array}{l} \text{--- } S. 180 - 101^\circ : 15' \end{array} \right\} - 88\frac{1}{2} \text{ Mil.}$
 Or $S. 78 : 45$

Note, When any Angle is greater than 90, subtract it from 180, and the Residue take out of the Table of Sines, to work with, as above.

2. By the Pen Arithmetical.

Assume a Perpendicular let fall from the Angle A, upon the Side CB, produced as A f : Then in the right-angled Triangle A B f, is given the Dist. A B 50m. and Angle A B f, $78^\circ : 45'$ (the Comp. of the Angle A B C to 180°) for if one Side (as CB) of a Triangle (A B c) be produced, the outward Angle (A B f) will be equal to the two inward and opposite Angles (B A C, and A C B) and all the three Angles (B A C, A C B, and A B C) shall be equal to two Right-angles, (or 180°) by the 22d of the first of *Euclid*.

5. From the Point C, let fall the Perpendicular CD, and it shall divide the oblique Triangle ABC, into two Right ones, ADC, and BDC.

6. Make DE = DB, so shall AD be the greater, DB, the lesser Segment; or Part of the Base AB, and AE, the Σ of those Segments; to find which Logarithmically,

$$\text{Prop. } AC \perp BC = \frac{Z}{X} \text{ Sides } \left\{ \begin{array}{l} 111m. \\ 19m. \end{array} \right\} \text{ Then,}$$

As Base AB .. Z Sides AC and BC :: X Sides, AC and BC .. X Segments of the Base AE; i.e.
As 58m. .. 111m. :: 19 .. — 36m.

Then AB 58 $\perp$ = E 36 = $\left\{ \begin{array}{l} 24 \\ 22 \end{array} \right\}$ the half of which

is the Base $\frac{AD}{DB} \left\{ \begin{array}{l} 47 \\ 11 \end{array} \right\}$

Then by Case 5. Plain-Sailing,

As AC .. R :: AD .. S. $\angle$ ACD
— 65m. S. 90° — 47m. — S. 46° 32' Whose
Comp. to 90° is the $\angle$ A 43° 28' from the East.
Therefore the Ship's Course was S. 46° 32' E.

As BC .. R :: BD .. S. $\angle$ BCD
— 46m. — S. 90° — 11m. — S. 13° 15'. So that the
Eastern Port bears N. 13° 15' E.

By the Pen and natural Arithmetick, in the Rule of
Three.

As Sd. AB .. Z Sds. :: Σ Sds. .. Σ Sgs. Base.
— 58 — 111 — 19 — 26m. AE.

Then proceed as before, to find the Bases AD and DB.

AB	58	—
x Segt.	36	—
Z	94	—
H	22	—
$\frac{1}{2}$ Z	47	=AD
$\frac{1}{2}$ x	11	=DB

The Angles ACD and
BCD may be found by Case
5th. of Plain-Sailing Arithmet-
tical.

Turning to Windward in Oblique Sailing.

3. I Shall now give some few Questions in this Sailing, useful to gain a Port in the shortest Time, when the Wind is contrary or scant.

A Ship, sailing to Windward, will usually lie within $5\frac{1}{2}$, or 6 Points from the Wind; but by reason of her Leeward-way, she will scarce make her Way good (with her Top-sails set) within $6\frac{1}{2}$, or 7 Points from the Wind; sometimes more, sometimes less, according as the Sea is rougher or smoother, and according to the Mould of the Ship, and Sail she bears: So that in sailing to a Place directly to Wind, she sails usually 3 or 4 times the Distance of that Place before she arrives at it. But if the Place she is bound to, be not directly to Windward, but within 1, 2, 3, 4, 5, or 6 Points of the Wind; then, tho' she turn to Windward, as before, yet she will sooner arrive at the Place than before: But how, and in what Proportion for the one, and for the other, may appear by the ensuing Problems, viz.

Prob. 1. The Wind East, and a Ship bound to an Island 80 Miles directly to Windward, making her Way good (when Variation Lee-way allow'd) within 6 Points, or $67^{\circ} : 30'$ of the Wind;

I demand her Distance upon each Tack to gain that Island?

Projection.

1. The Circle being describ'd, and quarter'd, as before, set off 8^{om}. from the Center A to the Port, and draw A B, the Dist. of the Port.

2. Set off 6 Rhumbs = $67^{\circ} 30'$ from E, the East Point, both Ways, toward the North and South; and draw Rhumb-Lines through these Points, as A C and A D (shewing how the Ship will lie on each Tack.)



3. From the Point B, draw B C parallel to A D, to cut A C in C, the Point where the Ship tacks. A C is the Star-board Tack, and C B the Lar-board, the Distance in each being equal, because the opposite Angles B and C are equal. Or, without the Circle, you may project it thus: Make A B = 8^{om}. pts. and the Angles B A C and A B C = each to $67^{\circ} \frac{1}{2}$, and draw A C and B C to intersect each other in C, the Place where the Ship goes about.

Logarithmetical, by Case 1. Oblique Sailing.

Prep. $\angle B + \angle A = 135^{\circ}$ and $180^{\circ} - 135^{\circ} = 45^{\circ} \angle C$.
 — As S $\angle C$.. Sd. A B :: Sd $\angle A$.. Side B C = A, C
 — S. 45° — 8^{om} — S. $67^{\circ} 30'$ — 104^m $\frac{1}{2}$ on each Tack.

Prob. 2. The Wind at East, and a Ship plying to Windward, having run 209 Lgs. that is, 104 L. $\frac{1}{2}$ with her Star-board Tack, and 104 L. $\frac{1}{2}$ with her Lar-board Tack on Board, is arrived at a Port 80 Leagues directly to Windward;

I demand how near the Wind she makes her Way good?

Project. See the last Scheme.

1. Make A B = 80 Lgs. and the Sides A C, and B C, each = 104 $\frac{1}{2}$ (as in Case 4th Ob. Sailing foregoing) and draw A C, and B C.

2. Let fall a Perpen. C E, from C, on A B, and 'twill divide the Base A B, equally in E, and the Oblique into two equal right-angled Triangles, A G E, and B C E; in each of which we have given A C, or, B C, 104 L. $\frac{1}{2}$ and $\frac{1}{2}$ A B = 40^m. to find the Angles at A or B, by Case 5th, Plain-Sailing.

K

there there

130 NAVIGATION. Turning

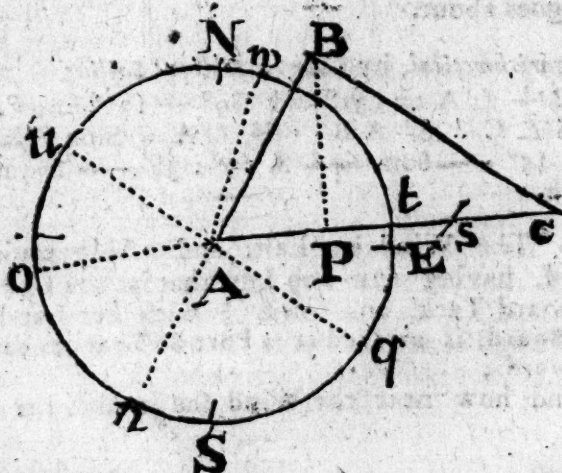
Therefore by *Logarithms*;

As *Sd.* AC .. R :: *Sd.* AE .. $S.C.S. \angle CAE$,
 $\frac{104m. 5. S. 90}{\text{the Comp. to } 90^\circ. \text{ is } 67^\circ : 30'}$ — $\frac{40m.}{\text{or } 6 \text{ Points from the}}$ — $S. \angle ACE 22^\circ : 30'$
 Wind she made her Way. Therefore,

Course on the { *Star-board* } Tack { *N. N. E.*
 { *Lar-board* } { *S. S. E.*

Probl. 3. Admit a Ship is bound to a Port that lies *N. N. E.* half *E.* distant 108 Leagues, the Wind being at *N.* by *E.* and she can lie no nearer the Wind than 6 Points; I demand her Distance upon each Tack, to gain the said Port?

Projection. The Circle being drawn and quarter'd as formerly, set off two Points from the *N.* toward the East, and draw the Wind-Line *A. w.*



2. Set off 6 Points = $67^\circ : 30'$ on each Side the Wind-line to *u* and *r*, and draw *A u* and *A r*.

3. Set off the Dist. of the Port 108 Leagues from *A* to *B*, on the *N. N. E.* Line *A B*, and through *B* draw *BC* parallel to *u A*, till it meets *A r* produc'd in *C*; then will *AC* and *ED* be the Distance on each Tack required.

Logarithmetical.

Logarithmetical. Vid. last Prob.

Then,

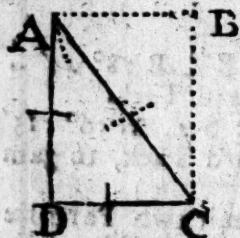
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of



Of Currents.

4. **C**urrents are certain Settings of the Stream, at Sea (or of the Tide in a River) by the means of which, all Bodies, (as Ships or Boats) mov'd therein, are compell'd to alter their Course, and submit to the Motion impress'd upon them by it: Thus in the following Scheme.



If a Body (or Ship) be agitated by two Motions at the same Time, the one with a certain Velocity (or Swiftneſs) that will carry her according to the Direction of the Line *AB*, the Length of *AB* in a certain Time; the other according to the Direction of the Line *AD*, with a Velocity that will carry her to the Dist. *AD*, in the same Time. I ſay, that the Body (or Ship) will deſcribe the Diagonal Line *AC*; and at the end of that Time will be found in the Point *C*.

From which it is plain, that when a Ship ſails in a Current, her Motion is compounded of two Motions; *viz.* The apparent Motion of the Ship, which is known by the Compaſs, Log, &c. And the Motion of the Current: The approved Method to find which, (as I have often practis'd in *West-India Voyages*, &c.) is thus;

When there is a ſmooth Sea, and not much Wind, hoist out your Boat, and take into her three or four Men, with a Compaſs, a Log-line, and a large Log, and half-minute Glaſs; alſo a Quoil or two of Inch Rope, (when you are a little from the Ship) which faſten to the Bayle of a large Kettle, or great Iron Pot; caſt over-board the Kettle, letting it ſink at leaſt 80, or 100, or 120 Fathom, (the more the better); then belaying the Rope about the Boat's Stem, it will bring her up, and make her ride as if at Anchor; then heave your Log, and turn up your half-Minute Glaſs (as you do in the Ship, to find her Diſtance run) and as you veer out the Log-line, ſet the Drift of the Log by your Compaſs; ſo ſhall you know if there be any Current or not, and if any, how it ſets, and the Rate of driving: As ſuppoſe you find the Current ſets Eaſt 1 half Knot in half a Minute, then is the

the Motion of the Current East, 36 Miles in 24 Hours : But you must observe, 1. To allow the Variation of the Compass (by the Rules hereafter given.

2. If the Rope be 80 Fathom allow $\frac{1}{4}$ Part ; if 100 Fathom $\frac{1}{2}$ Part, &c. of the Drift of the Current more for the Drift of the Boat ; for though the Boat seem to ride or lie still, yet she is found by Experience to drive at the same Time.

Having, by this Experiment, found the Quality and Quantity of the Current, the Ship's true Motion may be obtained by the following Problems.

1. If a Current set with the Course of the Ship, it augments her Velocity or Motion, by as much as is the Drift or Rate of driving of the Current.

Example. Thus if a Ship sail S. S. W. 45m. in 24 Hours ; and a Current sets S. S. W. 36 Miles in the same Time, her Course is S. S. W. 81 Miles : For 45m. more 36m. is equal to 81m.

2. If a Current set against the Ship, it lessens her Velocity of Dist. apparent) by just so much as is the Current's Drift.

Thus if a Ship sail S. W. 110m. in a Current that sets N. E. 24m. in the same Time, then her true Course will be S. W. 76 Miles ; for 110m. less 24m. is equal to 86 Miles.

Prob. 3. If the Ship thwart the Current, it not only lessens or augments her Velocity, but gives her a new Motion, compounded of that of the Ship and Current, (as is manifest in the preceding Scheme) which is not allow'd for in your Reckoning, you can never certainly, keep a Journal, or know the Place of your Ship ; therefore,

Case 1. Given Course and Motion of the Current, and Course and Dist. sail'd, to find the Course and Dist. made good ?

Examp. 1. Suppose a Ship sails S^o. 50m. in 24 Hours in a Current setting E. (that is, on the Beam or Broad-side, as the Sea-Phrase is) 36m. what is the Ship's true Course and Dist. run ?

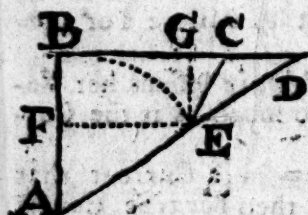
Construction. In the foregoing Projection A B C D. Let A D = 50m. be the Ship's Course and Dist. (which we may call her simple Motion) D C = 36m. the Current's Motion, A C the Line of the Ship's true Motion of Dist. and the Angle D A C the Ship's true Course.

Then, *Logarithmetical by Case 6. Plain-Sailing.*

As Simp. Mot. .. R :: Cur. Mot. T. Ship. tr. Course.
 — A D. 50m. — T. 45° . — D C. 36m. — $\angle DAC$ 35° .
 45'. the Ship's Course made good, is S. 35° . 45'. E.
 As S. tru. C .. Cur. Mot. :: R .. Dist.
 — S. 35° . 45'. — 36m. — S. 90° . — 61 Miles.

Examp. 2. A Current setting abast the Beam or Quarter, or before the Beam or Bow; as suppose a Ship sails N. E. 100 Miles in a Day, and a Current that sets E. 30 Miles in the same Time. I demand the Course and Dist. made good?

Projection Geometrical.



1. Draw A B, and project the Triangle A B C with the Course N E $= 45^{\circ}$. and Dist. 100m. as in Case 1 of Plain-Sailing.

2. Set off the Current's Motion 30 Miles from C to D, and draw the Ship's true Dist.

A D; then is C the Place of the Ship without, and D her Place with Allowance for the Current. Then,

Logarithmet. by Case 1. Plain-Sailing.

As R :: Dist. :: S. C. :: Depr.
 — S. 90° . — 100 — S. 45° . — 71m.
 Then 71m. + 30m. = B D } 101m. true Depr.
 B C + C D }

And the $\times$ Lat. A B is also 71m. because the Course is N E, or an Angle of 45° . therefore by

Case 6. Plain-Sailing,

As $\times$ Lat. .. R :: Depr. .. T. tr. Course.
 — 71m. — T. 45° — 101m. — N. 54° . 54'. E.

As S. C. 54° . 54'. .. Depr. 101m. R .. Dist. 133m.
 the Ship hath made good.

If the Current sets upon an oblique Course, and not due East, West, North, or South, the Operation will be as follows:

Examp. 3.

Examp. 3. Admit a Ship in 24 Hours sails N. E. 100m. in a Current that sets S. S. W. 30m. in the same Time; What is her Course and Dist. made good?

Projection.

1. Construct the Triangle A B C as in the foregoing Question, with the Course N. E. Dist. 100m.

2. Make C E a S. S. W. Line = 30m. that is, C A being a S. W. Line = 45° . and S. S. W. is = $22^{\circ} 30'$, therefore $45^{\circ} - 22^{\circ}$ and half = 22° and half. Make the Angle A C E $22^{\circ} 30'$ and draw also CE, and EF parallel to B C, also E G Parallel to A B, so shall the Angle E A F be the Ship's true Course, and A E her Dist. made good.

By the last Question, * Latitude A B was found to be 71m.

Then (the Angle C E G is = $22^{\circ} 30'$, and the Dist. E C 30m. because F G is a Meridian, and E C a N. N. E. Line; therefore by the Logarithms, Case 1, P. S.

As $\text{R} S. 90^{\circ}$. .. EC 30m. :: S. $\angle$ CEG 22° . :: GC 11m. 5

As $\text{R} S. 90^{\circ}$. .. EC 30m. :: S. $\angle$ ECG 67° . :: EG 27m. 7

Now B C = A B = 71m. — G C 11m. 5 = F E 59m. 5.

And A B 71m. — E G 27m. 7 = A F 43m. 3. Thus have we the Ship's true * Latitude or Northing 43m. and her true Departure or Easting 59m. given to find her Course and Distance made good.

By Case 6. Plain-Sailing.

As * Lat $43^{\circ} 3'$.. R :: Depr. 59. 5m. .. T. C. $54^{\circ} 54'$.
that is, Course is N $^{\circ}$. $54^{\circ} 54'$ E.

As S. C. $54^{\circ} 54'$.. Depr. 59m. $10'$:: R .. Dist. 72m. 8.

Note. In all these Examples where there is Course or Courses, and the Dist. sailed in 24 Hours, and the Setting and Drift of the Current in Quality and Quantity is given in the same Time; the Navigator need only put down the said Course and Drift of the Current among his other Courses and Distances by the Log, when he works his Traverse-Table, which is plain and easy, I think, without any Example, as the Learner may prove himself by the *Data*, and *Quests* of the foregoing Examples. Proceed we to

Case 2. Course and Dist. sailed, and Course and Dist. made good, given to find the Setting and Drift of the Current.

Examp. A Ship sails (by the Compass and Log) N^o. 54°. 54'. E. 73m. and then arrives at a Place which is known to bear from the Place sailed from N. E. 100m. (having been deceiv'd by an unknown Current) I demand which way the Current sets, and how fast, supposing the Ship to sail by the Log. 5 Miles an Hour?

Construction. Let AEF = 54°. 54'. the $\angle$ of the Ship's Course from the N^o. AE her Dist. 73m. AF = x. Lat. and FE her Dep. also the $\angle$ CAB the Course, AC the Dist. made good, given to find AB x. Lat. and BC her Depr. See the Scheme to Case 1. Ex. 2, draw EG parallel to AB, and draw EC; so shall the Angle CEG be the Course, and EC the Drift of the Current.

Logarithmetical.

1. As R. .. Dist. $\left\{ \begin{array}{l} \text{S. C. } 54^{\circ}. 54'. \\ \text{S. C. C. } 35^{\circ}. 06'. \end{array} \right. \text{Depr. FE } 260\text{m}$
 A E 73m. $\left\{ \begin{array}{l} \text{Lat. AF } 42\text{m} \end{array} \right.$

2. As R. .. Dist. AC 100m. $\left\{ \begin{array}{l} \text{S. C. } 70^{\circ}. 5 \text{ Depr. } 7 \text{ m} \\ \text{S. C. G. } 7^{\circ}. 2 \text{ Lat. } 71 \end{array} \right.$

3. x. Lat. A. B. 71m. — x. Lat. AF 42 = x. Lat. EG 29m. and Depr. BC 71m. — Depr. FE 60m = Depr. GC 11m. Then have we the x. Lat. 29, and Dep. 11m. of the Current given to find its Course and Dist. by Case 6. Plain Sailing. i. e.

As x. Lat. 29m. R. :: Depr. 11m. T. Course 20°. 45'.
 As S. C. 20°. 45' .. Depr. 11. :: R. x. Dist. 31m.

So that the Current sets N^o. 20°. 45'. E. 31m. in the Time that the Ship sailed N. E. 100m. Now if the Ship sails 5 Miles an Hour, she will be 20 Hours in sailing 100 Miles, in which Time the Current sets 31m. therefore divide 31m. by 20h. the Quotient is 1 Hour, 33 Minutes, the (Horary, or hourly Motion of the Current)

Case 3. Course and Distance between any two Places, and the Course and Motion of a Current that lies between them, given to find what Course to steer by the Compass, or how much to Windward of your true Course to steer, that so the compound Motion of the Ship, may just set her to her desired Place or Port.

Example.

Example. See the foregoing Scheme. There are two Ports A and D bearing S. W. half W. and N. E. a Dist. 123m. the Current sets E. 1. half Miles an Hour. I demand what Course the must steer from her first Port, and what Dist. by the Log she must run, to arrive at (D) her second Port.

Construction. 1. Lay down the Triangle ADB with the Course N. 50°. 37'. E. and Dist. 123m.
2. Then have you the Proportion of the Sides AC and C. D. and let E. represent the Motion of the Current 1. Mile and half an Hour, and A. the Motion of the Ship through the Water 4 Miles and half in an Hour.

Logarithmetical.

Because the Triangles ACD and AOE are similar; therefore the Angle AEO is = Angle ADB = 39°. 23' the Comp. of the Course. Then by Case 2. *Ob. Sailing.*

As A. 4.5m. .. S. $\angle$ AEO 39°. 23'. :: OE 1.5m. to the S. $\angle$ EAO 09°. 09'.

The Angle EAB = $\angle$ EAO = $\angle$ BAC, that is, 39°. 37'. = 09°. 09' is = N. 41°. 08'. E. the (Ship's) Course she must steer to the Port. Then to find AC the Dist. to run, by Case 1. *Ob. Sailing.*

$\angle$ D 39°. 23' + $\angle$ DAC 09°. 09' = 48°. 32'. $234^\circ - 48^\circ. 32' = \angle$ ACD 131°. 28'. Therefore

As S. $\angle$ ACD. Side AD :: S. $\angle$ ADC :: SA AC = S. 48°. 32'. = 123m. = S. 39°. 23'. = 104m.

the Dist. sailed by the Log is 104m. and the Rate of Sailing is 4 Miles and half an Hour; therefore divide 104 by 4.5, the Quote is 23 Hours that the Ship will be in Sailing from A to D.

Note. The faster the Ship sails, the less she needs to lye to Windward of her true Course against the Current, which is necessary to be known.

I might insert many other Curiousities in Current Sailing; but these being the most useful, I forbear to enlarge in this Place; therefore shall conclude this Sailing with another Method, to find where there is a Current at Sea, which way it sets, and how fast, and of turning to Windward in a Current.

The first may be done by comparing the Dead-reckoning outwards, with the Reckoning homewards after this Manner.

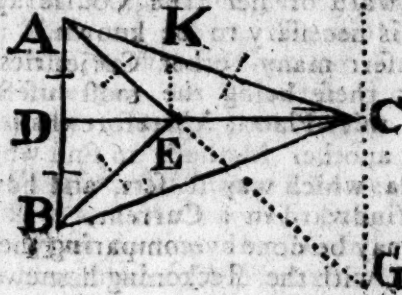
Exam. Admit a Ship sail from a certain Port (either upon one or several Courses,) till she arrives at a second, and there finds by her Dead-reckoning, that she is more Southerly than the Port from whence she departed by 53^m. and more Westerly by 334 Miles.

But by her Dead-reckoning homeward, when she arrived at the first Port she was only 487^m. to the Northward of the Second, and to the Eastward 300^m. so that the Difference of these two Reckonings is 45^m. Southerly, and 34^m. Westerly, which by the preceding Problem, the Current sets S. 37°. W. its Motion or Drift 56^m. Now let us suppose the Ship sailed from the first Port to the second in 4 Days, and from the second to the first in 5 Days, which is 9 Days time the Current set S. 37°. W. 56^m. therefore the Current's Motion is S°. 37°. W. 6^m. $\frac{1}{9}$. of a Mile in a Day.

2. Turning to Windward in a Current.

Exam. 1. **C**OURSE and Motion of the Current, and the Course and Dist. between two Ports, with the Point of the Winds blowing, and how near the Wind the Ship will lie, being given to find how long she must lie upon each Tack to gain her Port; supposing also that the Horary Dist. sailed by the Log be also given.

Admit two Ports bear North and South Dist. 270^m. the Wind at South, and a Current sets South 2^m. an Hour, a Ship is bound directly to Windward for the Southermost Port, and can lie within 72°. of the Wind, gets her Starboard Tacks aboard and sails 4^m. an Hour by the Log; it is demanded how long she must lay upon each Tack to gain the Port, and what Course she makes good?



Construction. 1. With the Dist. of the Ports $A B$ 270m. and Deg. 72. from the Wind at S^o . project the Triangle $A B C$, (as directed in *Prob. 1.* of turning to Windward in *Oblique Sailing* foregoing.)

2. $A C$ is $= B C$; let fall the perpendicular $C B$, and you have the right angled Triangle $A C D$, equal to the right angled Triangle $B C D$, and also the Side $A D$ equal to $D B = \frac{1}{2} A B$ 270m. viz. 135m. and the Angle $D C A = D C B =$ the Comp. of the $\angle C A B$ or $C B A$ 72^o . viz. 18^o . Then,

Logarithmic,

As $S. \angle A C D$.. Side $A D$:: $S.$ Side $A C$.
 $S. 18^o$.. 135m .. $S. 90$.. 436m.

the Dist. upon each Tack to gain the Port, if there had been no Current. Which 436 divided by 4m. sailed in an Hour quotes 109 Hours, in which the Ship sails from A to C ; but the Current sets South 2 Miles an Hour, and that in 109 Hours is $S. 218m$. Ergo, draw the South Line $C G = 218m$. and also $A G$, which shall represent the Compound Motion of the Ship, or Course made good; but because she is to lye upon that Tack, but only till she be got half way to the intended Port, observe where the Line $A G$ cuts the Perpend. $D C$, as in E , draw $A E$ and $B E$, so shall $A E$ be the Dist. on the Starboard, and $E B$ the Dist. on the Larboard Tack, to fetch the Port B , and the Angle $D A E$ the Course made good by reason of the Current.

But to find how far the Ship must sail by the Log, by that time she will be at E by the help of the Current, draw $E K$ parallel to $G C$; this Parallel shall cut $A C$ proportionably by *Euclid. Lib. 6. Prop. 2. viz.*

As $A G$.. $A E$:: $A C$.. $A K$. the Dist. sailed by the Log, (which found by the following Calculation) is 166. $\frac{1}{2}$. this divided by 4, the Miles sail'd by the Log in an Hour, gives 41 Hours, 37 Minutes, the time to stand upon the Star-board Tack, and the same time, on the Larboard Tack, to fall in with the Port bound for at B .

Calculation Logarithmic in the Oblique Triangle.

$A C G$ is given, the Side $C G$ 118m. and the Side $A C$ 436m. with the Angle between them $A C G$ 108^o . (for $C A$ is a Line $W. 18^o N^o$. and $C G$ a South Line, and from the $W. 18^o N^o$. to the S^o . is 108^o .) to find the Angle $C A G$, by *Case 3.* of *Oblique Sailing* foregoing, viz.

As

140 NAVIGATION; Turning

As Z : $Sds. 654$.. $\times Sds. 218$:: $T. \frac{1}{2} Z$ unknown, $\angle S$, 36° .. T , of half their $\times 13^\circ : 37'$. Then the $\frac{1}{2} Z$ 36° .. $00' - \frac{1}{2} \times 13^\circ : 37' = \angle CAG$ $22^\circ : 23'$. And the Angle $DAC = BAC$ 72° made less by the $\angle CAG$ $20^\circ : 23'$ is $49^\circ : 37'$ for the $\angle DAE$, whose Comp. to 90° is the $\angle AED$ $40^\circ : 23'$ as you may see in the Scheme.

To find the Dist. made good on each Tack $AE = EB$.

As $S \angle AED$.. $Sd. AD$:: B .. $Sd. AE$.
 $S. 40^\circ : 23' \text{ --- } 35m \text{ --- } S. 90 \text{ --- } 208m$,
 the Dist. made good on each Tack.

Then for the Dist. sail'd by the Log AK (which by the help of the Current she is carried to E .) in the Tri-angled AKE , is given AE $208m$ and the Angle AKE , $= \angle ACG$ 108° . Also the Angle $KAE = \angle CAG$ $22^\circ : 30'$, and the $\angle AEK = \angle AGC = \angle DAE$ $49^\circ : 37'$. viz. All the Angles and opposite Side AE , to find another opposite Side AK ; i. e. by Case 1. *Oblique Sailing*. Thus;

As $S \angle AKE$.. $Sd. AE$:: $S \angle AEK$.. $Sd. AK$.
 $S 180^\circ - 108 = 72^\circ - 208m - S 49^\circ : 37' - 168m \frac{1}{2}$.

Which divided by 4, the Miles sail'd in an Hour, the Quote is 41 Hours, 36 Min. that she must lie upon the Starboard Tack; in which time she is carried by the help of the Current, from A to E ; and then lying the same time upon her Larboard Tack, she will arrive at her intended Port B : So that in 83 Hours 12 Minutes, she performs the Voyage of 270 Miles, altho' upon a Wind, by the help of the Current; which had there been no Current would have requir'd (at the same Rate of Sailing) 218 Hours, or 9 Days, 2 Hours.

Examp. 2. When the Current sets Obliquely; that is, neither N. S. E. or West, and the Port bound to is also upon any other Point, and not on the aforesaid four Cardinals.

Suppose a Ship makes her way good within 6 and a half Points, (or $73^\circ : 07'$) from the Wind, being bound to a Port at P , bearing from A . S. W. by S. one quarter W. Dist. $476m$. the Wind at S. by W. A Current setting S. by E. 110 Miles in the same time that the Ship sails 300 Miles; I demand the Course and Dist. the Ship must sail upon her Starboard Tack AD , and what upon her Larboard Tack DE , to gain the said Port at P ?

Projection

1. The Circle describ'd and quarter'd as formerly directed.

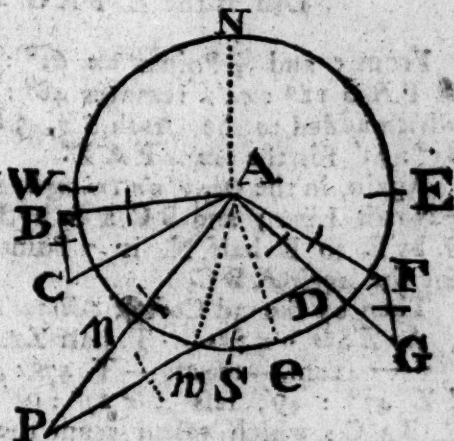
2. Set off 1 Rhumb, or $11^{\circ} : 15'$ from S to w, and from S to e, and draw A w, for the Wind-Line, and A e, for the Current's Motion, a S b, E. Line.

2. Set off 3 Points $\frac{1}{2}$ from S, towards W. and draw a S. W. by S $\frac{1}{2}$ West-line, and make A P' = 476m. the Dist. of the Port.

3. Set off $6 \frac{1}{2}$ Points, or $73^{\circ} : 07'$ from w, the Wind-line, both Ways, to B and F, and draw AB and BF, which is her Way upon the Lar-board and Star-board Tack, with-

out a Current: Make AB and BF, each equal to 300m. and from B and F, draw Parallels to A e, (the Line of the Current's Motion) and make BC and FG, each equal to 110m. and draw AC and AG, so shall C and G be the Place of the Ship on either Tack, with allowance for the Current.

4. Suppose the Ship gets her Star-board Tacks a-board at her first setting out; then draw from P a line parallel to AC, to cut AG in D, the Place where the Ship must Tack, so shall AD be her true Distance on her Star-board, and AP her Distance on the Larboard Tack, to gain her desired Port at P.



Operation Logarithmical.

In the Oblique Plain Triangle AGE, FA is a N. W. by W. half W. Line, and FG a S. by E. Line; from the one to the other is 11 Points and half, equal to $129^{\circ} 22'$. Therefore, by Case 3^d. Ob. Sailing,

NAVIGATION; Turning

$$\begin{array}{rcl} \text{As } Z \text{ Sds } \propto S_{ds} :: T. \frac{1}{2} Z \angle \propto T. \frac{1}{2} \angle \\ \text{--- } 410m. \text{--- } 190m. \text{--- } T. 25^{\circ} : 19' \text{--- } T. 12^{\circ} : 24' \\ \text{To which add} \quad 25 : 19 \end{array}$$

$$\text{Sum is equal to the } \angle A G F = 37 : 43$$

$$\text{Diff. is the } \angle F A G = 12 : 55$$

From 5 and $\frac{1}{2}$ Points $= 61^{\circ} : 52' = A. F.$ take the $\angle F A G 12^{\circ} : 55'$, remains $48^{\circ} : 57' E.$ the Arch $S. D.$ which added to the Arch $S. n.$ $3 P \frac{1}{4} = 36^{\circ} : 34'$, gives $85^{\circ} : 31'$ for the *Angle P A D.*

Again, in the *Ob. Plain Triangle*, $A B C$, $B A$ is an East, $\frac{1}{2}$ North Line; and $B C$ a S. by E. Line: From the S. by E. to E. half N. is 7 Points and $\frac{1}{2} = 84^{\circ} : 22'$ for the *Angle A B C.*

Then by the 3d Case of *Oblique Plain Sailing*,

$$\begin{array}{rcl} \text{As } Z \text{ Sds } \propto S_{ds} :: T. \text{ half } Z \angle \propto T. \text{ half } \angle \\ \text{--- } 410m. \text{--- } 190m. \text{--- } T. 47^{\circ} : 49' \text{--- } T. \text{ half } 27^{\circ} : 5' \\ \frac{1}{2} Z 47^{\circ} : 49', \text{ less } \frac{1}{2} \times 27^{\circ} : 05' = 20^{\circ} : 44' \text{ for the} \\ \angle B A C; \text{ which taken from the Arch } S B 7 \frac{1}{2} \text{ Points} \\ \text{equal } 84^{\circ} : 22', \text{ remains the Arch } S C \text{ equal } S 63^{\circ} : 28' \\ \text{West. So that the Line } C A, \text{ or its Parallel } P D, \text{ is a N.} \\ 63^{\circ} : 38' E. \text{ Line; and the Line } P A \text{ is N.E. by N. } \frac{1}{4} E. \\ \text{or N. } 36^{\circ} : 34' E. \text{ their Difference: or the } \angle \text{ con-} \\ \text{tain'd between them is } 27^{\circ} : 4', \text{ for the } \angle A P D. \end{array}$$

Also the Line $D A$ is N. $48^{\circ} : 57'$ West; and the Line $D P$ parallel to $C A$ is S. $63^{\circ} : 38'$ W. the *Angle* or *Archa* between these two is, $67^{\circ} : 25'$ for the $\angle A D P.$ (thus $48^{\circ} : 57' + 63^{\circ} : 38' = 112^{\circ} 35' - 180^{\circ} = 67^{\circ} : 25'.$)

So, we have now given in the *Ob. Triangle A P D* the $\angle A.$ $\angle P.$ and $\angle D.$ and Op. Side $A P.$ to find the other two Sides by Case 1. *Ob. plain Triangles.*

$$\text{As } S. \angle D \propto S_{d.} A P :: S. \angle P \propto S_{d.} A D.$$

$$\text{--- } S. 67^{\circ} : 25' \text{--- } 476m. \text{--- } S. 27^{\circ} : 04' \text{--- } 204m. 11^{\circ}.$$

The Distance made good on her Starboard-Tack.

$$\text{As } S \angle D \propto S_{d.} A P :: S. \angle P A D \propto S_{d.} D P.$$

$$\text{--- } S. 67^{\circ} : 25' \text{--- } 476 \text{--- } S. 85^{\circ} : 31' \text{--- } 514m.$$

the Distance made good on her Larboard-Tack. So that with allowance for the Current, the Ship must sail S. $48^{\circ} : 57'$ E. $234m. 1^{\circ}$, and $63^{\circ} : 38'$ W. $514m.$ and she will gain her intended Port.

Thus

Thus have we gone through the useful Questions in the several Kinds of Rectilinear Sailing :

I shall now proceed to the Solution of such Astronomical Problems as are useful in Navigation.

CHAP. V.

Astronomical Definitions.

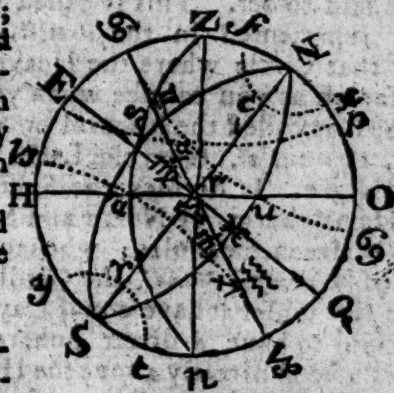
1. Of Points in the Heavens.

THE Zenith in *Arabick*, or *Vertex* in *Latin*, is the Point in the Heaven directly over our Heads, as Z.

And the Nadir in *Arabick*, is the Point under our Feet, as n.

2. Poles of the World (or Equinoctial) a *Greek* Word, signifying to run about ; properly, the North and South Points of the Heavens (or Earth) as North and South Poles of any great Circle, are 90° from that Circle.

Thus, the Zenith and Nadir are the Poles of the Horizon, &c.



The Center of the annex'd Circle is the Equinoctial Point of *Aries* and *Libra*. When the Sun cometh to these Points, he maketh equal Nights and Days all over the World ; which is about the 10th of *March*, and 12th of *September* ; from whence they are also termed Vernal and Autumnal Points.

The Center *V* and *S*, represents the East, or West Points of the Horizon, Morning and Evening; as also the Hours of 6 and 6, Morning and Evening. *H* is the South, and *O* the North Point of the Horizon.

2. Of Great Circles.

The Meridian is derived from Latin *Meridies*; *M* Mid-day. This Circle passeth thro the Poles of the World, and the Zenith and Nadir; also the North and South Points of the Horizon; unto this Circle (any Day in the Year) when the Sun cometh, 'tis Noon or Mid-day; and when the Moon, stars, or Planets, come to touch this Circle, they are then said to be upon the Meridian, or at the highest they will be that Night. This Circle is represented by the primitive Circle *H Z*. On.

2. Horizon is derived from the Greek Word *Horizen*, to bound, enclose, or terminate our Sight, and divides the upper, or visible, from the lower and invisible Hemispheres. To this Circle, when either the Sun, Moon, Stars, or Planets, come; on the East Part, they are said to Rise; and when they have passed from the Easterly Point by the Meridian; and descended to the Western Part of this Circle, they are then said to Set. This is called the Mathematical Horizon, and represented in the Projection by the Line *H V O*. But that Circle where the Heaven and Sea seem to meet, as far off as you can see when you turn your self about at Sea, is called the Natural or Sensible Horizon.

3. Equinoctial, from the Latin *Equus*, Equal; and *Nox*, the Night. It divides the Sphere into two equal Parts or Hemispheres, of North and South, lying in the middle between the Poles; whence by the Antients, it is called *Cingulum Mundi*, the Girdle of the World: Those that live under it have equal Days and Nights; and those are said to have a direct Sphere, because the Sun and Stars ascend directly above the Horizon, and descend as directly under it, the Poles of the World being in their Horizon; and we, and other Inhabitants, that have North or South Latitude, an Oblique Sphere; that is, the Sun and Stars rise and set at Oblique Angles to the Horizon, making unequal Days and Nights. Yet twice a Year, as was hinted before, have our Days and Nights equal, when the Sun cometh to this Circle. It is noted in the Scheme by *E Q*: and Note, that the Distance between the Equinoctial and Horizon of any Place,

is equal to the Comp. of its Latitude, as in the Scheme
 $EH = NZ = OQ = NS$.

Again, all the time the Sun is Northward of the Equinoctial, which is our Summer; those (if any there be that inhabit the North Pole of the World (and are said to have a parallel Sphere, because the Sun and Stars go parallel or round them in 24 Hours) have six Months Day, except what the Sun appears by Refraction) and during our Winter, which is the time when the Sun is to the Southward of the Equinoctial, they have six Months Night; and the contrary to these (if any) under the South Pole of the World.

4. *Ecliptick*. So called from the Greek Verb *Eclipseo*, which signifies to fail, or want Light; because under this Line the Sun and Moon are in the middle of the Zodiack, and always suffer their Eclipses. This Circle is called *Via Solis*, the Sun's Way, or Path, or Orbit, because he never goes out of it: This Circle is elevated above the Equinoctial in North Latitude $23^{\circ} \frac{1}{2}$, equal to the Sun's greatest Declination, and is as much depressed below the Equinoctial in the Southern Hemisphere; It cutteth the Horizon in the East and West Point Υ , as the Equinoctial did, and is represented in the Scheme by $\Theta \Upsilon \Psi$, and hath charactered upon it the twelve Zodiacal Signs; viz. The six Northern Signs, $\Upsilon \Theta \Pi \Theta \Lambda$ and Υ , being on that half that is above the Horizon; and the six Southern Signs, $\Lambda \Pi \Upsilon \Psi \Theta$ and Υ , on the other half, which is below the Horizon: And on this Line we count the Sun and Stars Longitude and Place in such a Sign, which is their Distance from the two Equinoctial Points, Υ and Λ .

5. *Of the Colures or prime Vertical.*

Colures. So called from the Greek Verb *Colao*, which signifies to join or glew together, because the other moveable Circles of the Sphere are (as it were) conglutinated, or united, by these. The Equinoctial *Colure*, *Prime Vertical*, or Circle of East and West, noted in the Scheme by $Z \Upsilon \Lambda$, passeth through the East and West Points of the Horizon unto this Circle, where, when the Sun, Moon, and Stars do (in their Motions) arrive, they are then due East or West.

The Solstitial *Colure* passeth through the Points of Cancer and Capricorn, the Zenith, Nadir, North and South Poles, and North and South Points of the Horizon, and is noted in the Scheme by the Primitive Circle or Meridian

dian ENQS. These two *Colures* divide the Equinoctial, Ecliptick and all the Heaven into four equal Parts, and shew the four principal Points of the Ecliptick, to which, when the Sun comes, he distinguishes each Quarter of the Year, *Spring, Autumn, Summer, and Winter.*

6. *Of Hour Circles, or Meridians.*

They meet together in the Poles of the World; and crossing the Equinoctial at Right-angles, and supposing the Equinoctial divided into 24 equal Parts, or Hours of a Natural Day: These Meridians may be drawn through every 15° . which is 1 Hour of Time; but if they pass through other Parts of the Equinoctial, dividing it unequally; then do those Hour-Circles represent unequal Spaces of Time, according to the Distance they are from the Meridian, or outward Circle of 12 at Noon and Midnight. The Axis of the World, N P S, is the six o' Clock Hour-line Morning and Evening, called also the Prime or first Meridian. So N. Q. S. and N. R. S. are unequal Meridians.

7. *Of Azimuth-Circles.*

Azimuth is an Arabick Word, signifying Vertical Circles, meeting together in the Zenith and Nadir-Points (as the Hour-Circles do in the Poles of the World) and divide the Horizon at Right-angles, either equal or unequal, as the Hour-Circles did the Equinoctial. They are represented in the Scheme by Z A u.

8. *Circles of Longitude* of the Sun or Stars, cut the Ecliptick at Right-angles, and intersect each other in the Poles thereof, which are 23° and half from the Poles of the World.

Arches of Great Circles.

1. The Sun or Star's Altitude, or Height in any Latitude is an Arch of an *Azimuth-Circle*, contain'd between the Sun and the Horizon, as E Q p.

2. *Amplitude* Latitude Width, is an Arch of the Horizon, and shews the Distance that the Sun or Star doth rise or set from the true East or West Points of the Horizon, towards the North or South Points thereof, as T u.

3. *Azimuth* is an Arch of the Horizon, contained between the Point where the *Azimuth-Circle* that the Sun is in cuts the Horizon, and the North and South Points of the Horizon. The Sun's *Azimuth* from the South is represented in the Scheme by H a; from the North by the Arch O a.

4. *Right*

4. *Right Ascension* is an Arch of the Equinoctial, between the beginning of *Aries* (or in Astronomical Operations, between the nearest Equinoctial Point) and that Point of the Equinoctial that comes to the Meridian with the Sun or Star; as $\gamma \kappa$.

5. *Oblique Ascension* is an Arch of the Equinoctial, contain'd between the next Equinoctial Point, and that Point of the Equinoctial that rises with the Sun, or Star.

An *Oblique Descension* is the Arch of the Equinoctial which setteth with the Sun, or Star.

6. *Ascensional Difference* is the Difference between the Right and Oblique Ascension; or it is an Arch of the Equinoctial contain'd between the Points of Right and Oblique Ascension; and consequently shews how long the Sun rises or sets before or after the Hour of 6: Or half the Time that a Star above or below our Horizon exceeds, or wants, of 6 Hours.

7. *Longitude* of the Sun or Stars, is an Arch of the Ecliptick, contain'd between the next Equinoctial Point and the Sun, or Star; as $\alpha \eta$.

8. *Declination* is an Arch of the Meridian, contained between the Equinoctial and the Sun, as $Q \odot \kappa$, and sheweth how far the Sun, or Star is to the Northward or Southward of the Equinoctial.

9. *Latitude* of a Star is an Arch of a Circle of Longitude, comprehended between the Star and the Ecliptick.

Lesser Circles.

They are commonly parallel to some great Circle; and hence called *Parallels*; as *Parallels of Altitude*; as $E \alpha p$; and *Parallels of Latitude, or Declination*; as $\odot \kappa$.

The *Tropick* (from the Greek, *Trope*; a conversion, or turning; Because the Sun there is in its greatest Declination from the Equinoctial, and turns backward) of *Cancer*, is a Parallel to the Equinoctial, distant $23^{\circ} \frac{1}{2}$ Northward, and the *Tropick of Capricorn*, the like Distance Southward; as $\odot \odot$, and $\vee \vee$. The *Arctic*, (or North polar) Circle is distant from the Equinoctial Northward, and the *Antarctic* (or South polar) Circle, Southward, $66^{\circ} \frac{1}{2}$; as $f c x$, and $y r t$. These two Tropicks, and two polar Circles, do divide the Globe into 5 Zones. (*Zona* is Latin for a Girdle) the Spaces between the two polar Circles and their respective

Poles, are called the two *Frozen Zones*. The two Spaces between the polar Circles and the Tropicks of *Cancer* and *Capricorn*, the *Temperate Zones*; And the middlemost between the two Tropicks, the *Burning Zone*.

Angles.

The Sun's greatest Declination is the Angle that the Ecliptick makes with the Equinoctial, as the Angle $\angle E$ $\angle \text{or } Q \angle \text{VS.} = 23^{\circ}. 30'$.

The Sun's Azimuth is an Angle at the Zenith, contained between the Azimuth-Circle the Sun is in; and the Prime-Vertical (if reckon'd from the East or West) or the Meridian, if reckoned from the North or South: Thus the Angle $\angle Z a$, is the Sun's Azimuth from the East or West; but $\angle O Z a$ is the Sun's Azimuth from the North, and $\angle a z b$ his Azimuth from the South; either of which may be measured on the Horizon $H O$ from the Line of $\frac{1}{2}$ Tangents.

The Hour of the Day is an Angle made at the Pole, between the Meridian of the Sun, and the Meridian of the Place: Thus the Angle $\angle N. E.$ is the Hour from Noon, when the Sun is any where in the Meridian $N. \angle S$; and $\angle N \angle$ is the Angle from 6 a-Clock in the Morning, $\angle N \angle$ the Angle of the Hour from 6 in the Evening, and $\angle N Q$ the Angle of the Hour from Midnight. All these may be measured from the Equinoctial by a Line of $\frac{1}{2}$ Tangents; because all the Angles in *Astronomy*, may be reckoned Arches of those great Circles that are 90 Deg. distant from the angular Point.

I thought here to have given you the Orthographic and Stereographic Projection of the Sphere on any Circle, and the Doctrine of Spherical Triangles, and all the Variety of Questions in *Practical Astronomy*; but that being sufficient to make a Treatise it self, which would exceed the design'd Limits or Bounds of this small Book; I rather chose to supply that defect by inserting such practical Problems of *Astronomy*, as are of most use in Navigation, and *Astronomical Tables* ready calculated from them. And as for the curious Learner, that would gain a further Improvement in *Astronomy*, I refer him to the latter Part of this Treatise, where I hope he may receive ample Satisfaction, and pass on to

ASTRONOMICAL PROBLEMS.

Prob. 1. *Given the Day of the Month; required the Sun's Place in the Ecliptick.*

K EEP in Mind the Days on which the Sun enters the several Signs, which are these;

♈	♉	♊	♋	♌	♍
Mar. 10.	Ap. 9.	May 10.	June 11.	Jul. 12.	Aug. 12.
♎	♏	♐	♑	♒	♓
Sep. 12.	Oct. 12.	Nov. 12.	Dec. 11.	Jan. 9.	Feb. 8.

Rule. If at the Day given the Sun be in the Sign proper to the given Month; subtract the Day the Sun enter'd that Sign from the Day given; multiply the Remainder into $59^{\circ} . 8' . 19'' . 43''' . 47'''' . 21''''' . 29''''''$ (the Sun's Motion in the Ecliptick in one Day) but $59^{\circ} . 8''$ may suffice (for common Use) so you have the Degree of that Month's Sign the Sun is in.

Exam. I demand the Sun's Place on the 25th Day of August? $25 - 12 = 13 \times 59^{\circ} . 8'' = 12^{\circ} . 58' . 44''$ of ♎. See the Operation.

$$\begin{array}{r}
 59 : 8 \\
 \hline
 59 : 54 : 48 \\
 \hline
 11 : 59 : 36 \\
 + : 59 : 08 \\
 \hline
 \end{array}$$

☉'s Place $12 : 58 : 44$ of ♎.

Multiply by the Ratio of 12 Days, i. e. 6 and 2, and add to the Product $59^{\circ} . 8''$ for the odd Day.

Exam. 2. If the Sun be in a Sign different from the proper Sign of the Month; then from the Number of Days contained in the preceding Month, subtract the Day of the Sun's entering into that Month's Sign; to the Remainder add the Day of the Month given; that Sum multiplied into $59^{\circ} . 8''$ exhibits the Degree the Sun is in.

Examp. August the 6th, the Sun is in Ω $24^{\circ}. 38'. 21''$.
for July 31 Days—12 Days in Aug. the Sun enters Ω $=$
19; which added to the given Day of the Month 6,
is 25.

Operation.

$$31 - 12 \div 6 = 25 \text{ Days.}$$

59'. 8".

8

-7 : 53 : 04

3

23 : 39 : 12

† : 59 : 08

24 : 38 : 20 of 2

Multiply
by the Ra-
tio of 24.
viz. 8 and 3,
and add to
the Product
59'. 8". for
the odd Day.

Lemma. 1. The Sun's Place given to find the nearest Equinoctial Point.

Rule. Divide the Ecliptick into 4 Quadrants or Quarters thus :

1. Qr. ♀. ☿. ♀. } While the Sun is in the first
2. Qr. ☿. ♀. ♀. } and last Quadrants, ♀ is the
3. Qr. ♀. ♀. ♀. } nearest Point; and when in
4. Qr. ♀. ♀. ♀. } the middle two, ♀.

In the first Quadrant, the Sun's Longitude is the Distance from the nearest Equinoctial Point.

In 2. Qr. 180° . — $\odot$'s Long.

In 3. Qr. ♂'s. Long — 180.

In 4. Qr. 360 — G's. Long.

Prob. 2. The Sun's greatest and least Meridian Altitude (taken at Noon on the longest and shortest Days of the Year at London) given, to find the Sun's greatest Declination, and the Latitude of the Place?

Exam.

Example. With a Quadrant, (Forestaff) or other Instrument; suppose I had observ'd on

June } the 11th } Sun's Merid. Alt. to be } $\begin{matrix} 61 : 58 \\ 14 : 58 \end{matrix}$

Their α . is the Dist. of the Tropicks = $47 : 00$

The half of which is Sun's great Declin. = $23 : 30$

Merid. Alt. } $\begin{matrix} 61 : 58 \\ 14 : 58 \end{matrix}$ } taken from

90°. gives } $\begin{matrix} 28 : 02 \\ 14 : 02 \end{matrix}$ } Sun's Zenith

$\times 75 : 2$

Distance on } $\begin{matrix} \text{June} \\ \text{December} \end{matrix}$ } 11th

To ☉'s Zenith Distance — S°. $28 : 02$ } June 11th;
Add ☉'s Declin. — N°. $23 : 30$ }

Lat. of London N°. = $51 : 32$ N°.

From ☉'s Zen. Dist. $75 : 02$ S. }
Take ☉'s Decl. — $23 : 30$ S. } Dec. 11th.

Rest. Lat. London $51 : 32$ N°.

Prob. 3. Given the Sun's greatest Declination and Place; required the present Declination, and Right Ascension?

Exam. The Sun in $27^\circ. 30'$. of ☉ Taurus, and his greatest Declination, (always) $23^\circ. 30'$. N°. (or S°.) given; what is his present Declination, and Right Ascension?

Projection Geometrical.

1. With the half Tangent $90^\circ =$ Chord of 60° , describe the Meridian or Circle ENQS , and quarter it as before taught.

Calculation Logarithmetical.

The Sun's present Declination is found by the Rule of opposite Sides and Angles: Thus,

As Σ .. S. $\odot$ Long. : : S. $\odot$ grt. Dec. .. S. $\odot$ pr. Decl.
— S. 90° . — S. $57^\circ 30'$. — S. $23^\circ 30'$. — S. $19^\circ 39'$. N $^\circ$. be-
cause the Sun is in a Northern Sign.

As Σ .. S. C. $\odot$ grt. Dec. : : T. $\odot$ Long. .. T. $\odot$ R. Asc.
— S. 90° . — S. $66^\circ 30'$. — T. $57^\circ 30'$. — T. $55^\circ 13'$. from Υ .

By Gunter's Scale Instrumental.

The Ext. } from $\{ \text{S. } 90^\circ \text{ to S. } 57^\circ 30' \} \odot \text{ Longit. T. } \odot$
reaches } gr. Dec. $23^\circ 30'$ to the S. $\odot$ present
Declin. on the Line of Sines, viz. $19^\circ 39'$.

The Ext. } $\{ \text{S. } 90^\circ \text{ to S. } 66^\circ 30' \} \odot$
reaches } $\{ \text{S. } 57^\circ \frac{1}{2} \text{ to T. } 55^\circ 13' \} \odot$ on $\{ \text{Sines.} \}$
Tang.

N. B. In the 1st Quadrant Υ B is the right Ascension,

In 2. Qr. $180 - \Upsilon$ B } is the right Ascension

In 3. Qr. $180 + \Upsilon$ B } is the right Ascension

In 4. Qr. $360 - \Upsilon$ B } is the right Ascension

By this Problem may the Tables of the Sun's Declination and Right Ascension, (at the latter End of this Book) be calculated, the Sun's Place in the Ecliptick given; for the Sun's greatest Declination is always $23^\circ 29'$, but by the exact Observations of Mr. Flamsteed, $23^\circ 29'$.

By the reverse of this Problem also may Prob. 4. and 5. be performed, in which I shall (to avoid Prolixity) be very brief, and leave the Operation to the Learner.

Prob. 4. Given the Sun's present Declination $19^\circ 39'$ North, and right Ascension $55^\circ 13'$ from Υ , to find the Sun's Place and greatest Declination.

Construction. [See the last Scheme.]

1. Make Υ B = Tangent Sun's Right Ascension $55^\circ 13'$. (the Circle being first described and quartered, as before directed).

2. Thro' the Points N B and S, describe the Meridian (or Arch of a Circle N B S) and find the Pole thereof, as directed in the preceding Prob.

3. Make $\text{Ae} d$ = Chord of $\odot$ Decl. $19^\circ 39'$; and laying a Ruler over d and p , to cut N B S in T. Lastly, thro' T and the Center Υ , draw the Ecliptick Line E T Υ C, and it's done.

Calcul. Logarithmetica.

As $\mathbb{R} \dots \text{S. C.} \odot \text{pr. Dec.} :: \text{S. C.} \odot \text{R. Asc.} \dots \text{S.} \odot \text{Place}$,
or Long. $57^{\circ} : 30' - 30^{\circ} = 27^{\circ} : 30'$ of $\odot$.

As $\text{T.} \odot \text{pr. Dec.} \dots \mathbb{R} :: \text{S.} \odot \text{Rt. Ascen.} \dots \text{T. C. of}$
the Sun's greatest Declination, $23^{\circ} : 30'$.

Prob. 5. Given Sun's $\left\{ \begin{array}{l} \text{pref.} \\ \text{great} \end{array} \right\}$ Dec. $\left\{ \begin{array}{l} 19^{\circ} : 39' \text{N.} \\ 23^{\circ} : 30' \end{array} \right\}$

Req. Sun's $\left\{ \begin{array}{l} \text{Longitude.} \\ \text{Right Ascension.} \end{array} \right\}$

Projection. [See the last Scheme.

1. Make $\mathbb{A} \text{E} = \text{Chord } 23^{\circ} : 30'$ and draw the Ecliptic $\text{E} \vee \text{C}$.

2. Make $\text{N} d$ and $\text{N} e = \text{Com. Declin. viz. } 70^{\circ} : 21'$ from the Chords. Then with the Tang. of $70^{\circ} : 21'$ and one Foot in E and e , describe two Arches to intersect each other above N . Then with the same Dist. one Foot in the said Intersection, describe the Parallel of the Sun's (Diurnal Course) Declination $d \text{ T} e$, to cut the Ecliptick Line $\text{E} \vee$ in T .

3. Through the 3 Points N T S , describe a Circle, or Meridian, N T B S , and it's done. Then,

Logarithmetical.

As $\text{S.} \odot \text{gr. Decl. S.} \odot \text{pref. Decl.} :: \mathbb{R} \dots \text{S.} \odot \text{Long.}$
from $\vee$ $57^{\circ} : 13'$.

$\mathbb{R} \dots \text{T.} \odot \text{pref. Decl.} :: \text{T. C.} \odot \text{great Decl.} \dots \text{S.} \odot$
Right Ascension from $\vee$ $55^{\circ} : 30'$.

Prob. 6. If the Sun's Long. and Ascension were given, to find the Sun's present and greatest Declination, which is the reverse of the last Prob. Then it is,

As $\mathbb{R} \dots \text{T.} \odot \text{Rt. Ascen.} :: \text{T. C.} \odot \text{Long.} \dots \text{S. C.} \odot$
present Declination.

Again.

As $\text{S. C.} \odot \text{Rt. Ascen.} \mathbb{R} :: \text{S. C.} \odot \text{Long.} \dots \text{S. C.} \odot$
greatest Declination.

Prob. 7. If the Sun's Longitude and present Declination were given, to find the Sun's greatest Declination and Right Ascension, the Proportions are,

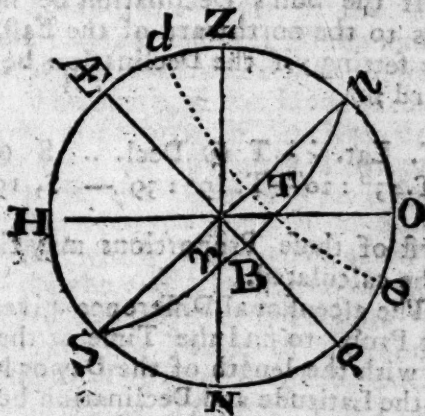
As S. $\odot$ Longit. .. R. :: S. $\odot$ present Decl. .. $\odot$
greatest Declination.

As S.C. © pref. Decl. .. R : : S. C. © Long. .. S.C. ©
Right Ascension.

Prob. 8. The Latitude of the Ship (or Place) $43^{\circ} : 20'$ N^o. and the Sun's Declination ($19^{\circ} : 39'$ N.) given ; to find the Sun's Amplitude, and ascensional Difference, which is the time of the Sun's Rising or Setting from the Hour of 6.

Projection

3. The Circle being described (with a Chord of 60°) and quartered, make Z the Zenith, N the Nadir, and H γ O, the Horizon; H the South; O the North; and γ the East or West Points thereof.



2. Make $O\pi$, and $Z\Xi$, each equal to the Chord of the Lat. $43^{\circ}:10'N$, and draw the Axis $N\Upsilon S$, and the Equinoctial $\Xi\Upsilon Q$.

3. Because the Declination given is North, describe a Parallel of the Sun's Declination, ($70^{\circ} : 21'$) from π the North Pole, as was directed in the 5th Problem foregoing, and it will cut the Horizon in T.

4. Through the Points γ T and S, describe the Meridian Circle γ T S, which cuts the Equinoctial in B; so shall γ T be the Sun's Amplitude from the East or West; and γ B the ascensional Difference; and both of them measured from the Center γ by a Line of half Tangents; but to determine their just Qualities by Calculation Logarithmetical, these are the Proportions;
viz.

In the Right-angled spherical Triangle $\nabla B T$, Right-angled at B , is given the $\angle T \nabla B$, the Comp. of the Lat. and $B T$ the Sun's Declination; to find ∇T , the Sun's Amplitude, and ∇B , the ascensional Difference (by opposite Sides and Angles.)

As S. of $\odot$. Lat. .. S $\odot$ Decl. :: R .. S. $\odot$ Ampl. —
S. $46^{\circ} : 40'$ — S. $29^{\circ} : 39'$ — S. 90 — $27^{\circ} : 32'$

That is, E. $27 : 32'$ N. } which turn'd into Points of
And W. $27^{\circ} : 32'$ N. } the Compass, gives nearest,

E. N. E. $\frac{1}{2}$ N. } at $\frac{1}{2}$ Sun-rising.
And W. N. W. $\frac{1}{2}$ N. } at $\frac{1}{2}$ Sun-setting.

For, Note, If the Sun's Declination be northerly, the Amplitude is to the northward of the East, or West at Sun-rising or setting; if the Declination be southerly, to the Southward;

As R .. T. Lat. :: T $\odot$ Decl. .. S $\odot$ Ascen. π
— T. 45° . T. $43^{\circ} : 20'$ — T. $19^{\circ} : 39'$ — S. $19^{\circ} : 41'$.

By the first of these Proportions may the Tables of Amplitude be calculated.

Prob. 9. The ascensional Difference given, or found, as in the last Prob. to find the Time of the Sun's rising or setting; with the length of the Day or Night.

Rule 1. If the Latitude and Declination be both North, or both South, the ascensional Difference added to 6 Hours, gives the Time of Sun-setting; and subtracted therefrom, Sun-rising. And contrary, if one be North, and the other South, the ascensional Difference added to 6 Hours gives the Time of Sun-rising; and subtracted therefrom, the Time of Sun-setting.

Example 2.

Let the Latitude be $43^{\circ} : 20'$ No. and Sun's Declination, $19^{\circ} : 39'$ N. and the ascensional Difference as in the last Prob. $19^{\circ} : 41'$. Then,

	5) 19 : 41 (	5 Divide by the Ratio of 15. viz. 5 and 3.
	<u>3) 3 : 56 : 12"</u>	
Hours	<u>1 : 18 : 44"</u>	Sun's Ascen. x. in Time
Add	<u>6 : 00 : 00</u>	Hours.
Hours	<u>7 : 18 : 44"</u>	Time of Sun-setting.
Subt. is	<u>4h : 41 : 16"</u>	Time of Sun-rising.
☉ R. Doub.	<u>4h : 37 : 28</u>	= Length of the Day.
☉ S. Doub.	<u>9h : 22 : 32</u>	= Length of the Night.

Rule. 2. Is because the Hour of the Sun's setting, shews the Time elapsed between Noon and the End of the Day; and which is therefore equal to half the length of the Day. Therefore, if the Hour of Sun-setting be doubled, it gives the Length of the Day, or Number of Hours the Sun is visible above the Horizon.

Again; because the Hour of Sun-rising shews the Time elapsed, between the Time of the Sun's rising and Mid-night; and which is therefore equal to half the length of the Night. If the Hour of Sun-rising be doubled, it gives the length of the Night.

By this *Prob.* may our Tables of the Sun's rising or setting, and length of Day or Night be calculated.

Also in the foregoing Triangle $\nabla B T$, may the succeeding Problems, 10 and 11, be resolved, viz.

Prob. 10. If the Sun's true Amplitude observed (at Sea) were $27^{\circ} : 32' N.$ and the Sun's Decl. $19^{\circ} : 39' N.$ and the Sun's Decl. $19^{\circ} : 39' N.$ also given, to find the Latitude of the Ship or Place? The Proportions are,

As S. ☉ Amp. .. R : : S ☉ Decl. .. S. of Co. Lat.
— S. $27^{\circ} : 32'$ — S. 90 — S. $19^{\circ} : 39'$ — S. — $46^{\circ} : 40'$.
Whose Comp. to 90° is the Lat. $43^{\circ} : 20'$ North.

Prob. 11. If the Time of the Sun's rising 4h. 41' : 16", or setting 7h 18' : 44", consequently the ascensional Difference $19^{\circ} : 41'$, with the Sun's Decl. $19^{\circ} : 39' N.$ were given; to find the Lat. Then,

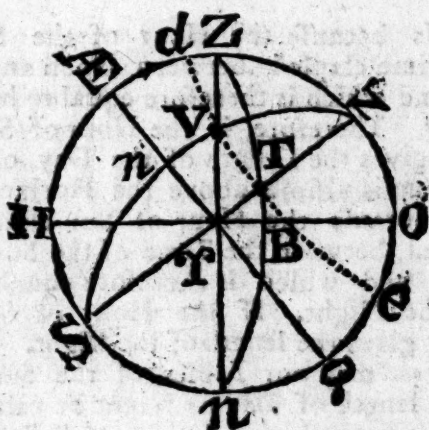
As T ☉ Decl. .. R : : S. ☉ Ascen. x. .. T. Lat. —
T. $19^{\circ} : 39'$ — S. 90 — S. $19^{\circ} : 41'$ — T. $43^{\circ} : 20' N.$

These

These Problems 10 and 11, may be of good Use to the Mariner, when he cannot have an Observa- tion at Noon for the Lat. but by the Benefit of a clear Evening; having obtain'd the Sun's Amplitude (with allowance for Variation of the Compass) and the Declination, for the Time given; (or the true Time of the Sun's setting observ'd) he may, by the help of these, find the Lat.

Prob. 12. The Lat. of the Place, (suppose $35^{\circ} 32' N.$) and the Sun's Declination (admit $23^{\circ} : 30' N.$) given; to find the Sun's Altitude (Height) and Azimuth at the Hour of 6?

Projection.



1. Having describ'd the Circle and quartered it, set off the Lat. and draw the Parallel of Declination, as directed Prob. 8th and 5th. The Parallel of Declination cuts the Axis N $\vee$ S in T. Then (2.) Draw throug Z, the Zenith Point, the Point T, and the Nadir, n; an Azimuth Circle, ZTB n, it will form the Right-angl'd-spherical Triangle $\vee$ BT Right-angled at B, the Axis N $\vee$ S is the 6 o' Clock Hour-circle; and B T is the Sun's Altitude, and $\vee$ B on the Horizon, the Sun's Azimuth, from East or West at the Hour of 6. Each of which may be measur'd by Prob. 3.

Calculation Logarithmetica

For the Sun's Altitude, 'twill be by the Rule of opposite Sides and Angles,

As $R \propto S. \vee$ Decl. $\vee T :: S. Lat. \cdot S. Sun's Alt.$ at 6.— $S. 90^\circ$ — $S. 23^\circ : 30'$ — $S. 35^\circ : 32'$ — $S. 13^\circ : 24'$.

For the Sun's Azimuth from the East or West,

As $T. C. Sun's Decl. \cdot \cdot :: S. C. Lat. T. Sun's Azim.$
— $T. 66^\circ : 30'$ — $S. 90^\circ S. 54^\circ : 28'$ — $19 : 28'$ East ;
Northerly, if in the Morning ; or West-northerly, if in the Evening. Wherefore the Sun's Azimuth $19^\circ : 28'$ subtracted from 90° , gives the Azim. from the N. $70^\circ : 32'$ East, or near the E. N. E. $\frac{1}{4}$ E. in the Morning.

Again, the Sun's Azimuth $19^\circ : 28'$ found above, added to 90° , gives the Sun's Azimuth from the South $109^\circ : 28'$ towards the East, if it be in the Morning ; but if the Observation had been in the Evening, the Sun's Azimuth would have been W. N. W. $\frac{1}{4}$ W.

Note, If the Declination be contrary to the Lat, that is, if one be North, the other South ; then, instead of the Altitude, before-found, it gives the Depression, and shews how many Degrees the Sun is below the Horizon at the Hour of 6.

Prob. 13. If in the Triangle above, *viz.* $\vee B. T$, were given the Sun's Altitude at the Hour of 6, ($13^\circ : 24'$) and Declination ($23^\circ : 30'$) to find the Latitude and Sun's Azimuth at the same time ; then say by the Rule of Opposite Sides and Angles,

As $S \odot$ Decl. $\cdot \cdot R :: S. \odot$ Height $\cdot \cdot S. Lat.$
— $S. 23^\circ : 30'$ — $S. 90^\circ$ — $S. 13^\circ : 24'$ — $S. 35^\circ : 32' N.$

Again,

As $S. C. \odot$ Alt. $\cdot \cdot R :: S. C. \odot$ Decl. $\cdot \cdot S. C. \odot$ Az.
As $S. 76^\circ : 36'$ — $S. 90^\circ$ — $S. 66^\circ : 30'$ — $S. C. 19^\circ : 28'$

Whose Comp. to 90° . is the Sun's Azimuth from the Meridian, or North and South $70^\circ : 32'$.

Prob. 14. If the Altitude ($13^\circ : 24'$) and Azim. ($19^\circ : 28'$) were given, (in the aforesaid Triangle) to find the Lat. and Sun's Declination,

Then 'twill be,

Astronomical Problems.

As T. Sun's Alt. .. R :: S. Sun's Azim. .. T. C. Lat.
 — T. $13^{\circ} : 24'$ — S. 90° — S. $16^{\circ} : 28'$ — T. $54^{\circ} : 28'$
 Whose Comp. to 90° is the Lat. $35^{\circ} : 32'$ North.

Again,

As R :: S. C. © Alt. :: S. C. © Azim. .. S. C. © Decl
 — S. 90 — S. $76^{\circ} : 36'$ — S. $70^{\circ} : 32'$ — S. $66^{\circ} : 30'$
 Whose Comp. to 90 is the Decl. $23^{\circ} : 30'$ North.

Prob. 15. The Lat. of the Place; (suppose $35^{\circ} : 32'$ North) and the Sun's Declin. (as before $23^{\circ} : 30'$ N.) given; to find his Altitude, and the Time when he is due East or West.

In the last Scheme to Prob. 12. having drawn the Circle, quarter'd it, and set off the Lat. drawn the Axis, N V S; Equinoctial AEQ, and the Parallel of the Declination, d T e, which cuts the prime Vertical, or first Azimuth, V Z in V, then through N V and S, draw the Meridian N V S, cutting the Equinoctial at Right-angles in the Point n. So that in the Right-angled Triangle V n v, will be given the $\angle U V n$, the Lat. and the Sun's Declinat. n v; to find the Sun's height, V v, and Hour from 6, V n; each of which is measur'd on the half Tangents; Logarithmic. by the Rule of opposite Sides and Angles.

As S. Lat. .. S. Sun's Decl. :: R :: S. Sun's Alt. E. or W.
 — S. $35^{\circ} : 32'$ S. $23^{\circ} : 32'$ — S. 90 — S. $43^{\circ} : 19'$ —

Again;

As R = T. C. Lat. :: T. Sun's Decl. .. S. hour from 6.
 S. 90 — T. $54^{\circ} : 28'$ — T. $23^{\circ} : 30'$ S. $37^{\circ} : 25'$
 which reduced into Hours (is $1^h : 49' : 40''$) and shews how long after 6 in the Morning it is e'er the Sun be due East, and how long before 6 in the Evening the Sun comes to the West. Wherefore to 90° , or — — — — — $6^h : 00' : 00''$
 add the Time above — — — — — $1 : 49 : 40$

Sum is the Time the Sun is }
 due East in the Morn. } — — — $7 : 49 : 40$

Or,

From 90° = — — — — — $6 : 00 : 30$
 Subtract the said Time — — — — — $1 : 49 : 04$
 Rem. the Time the Sun is due West in }
 the Afternoon. } $4 : 10 : 20$

Note,

Note. If the Lat. and Declination given had been one North, and the other South, the Sun would be under the Horizon, and the Question of no use.

Prob. 16. In the same Triangle $\Upsilon n v$. let there be given the Sun's Height ($43^\circ : 19'$) and Declination ($23^\circ \frac{1}{2}$ North) to find the Lat. and Hour of the Day? Then say, By the Rule of opposite Sides and Angles,
As S. $\odot$ Alt. $\dots$ Υn $\dots$ S. $\odot$ Decl. $\dots$ S. Lat.
— S. $43^\circ : 19'$ — S. 90 . — S. $23 : 30'$ — S. $35^\circ : 32' N$.

Again, for the Hour.

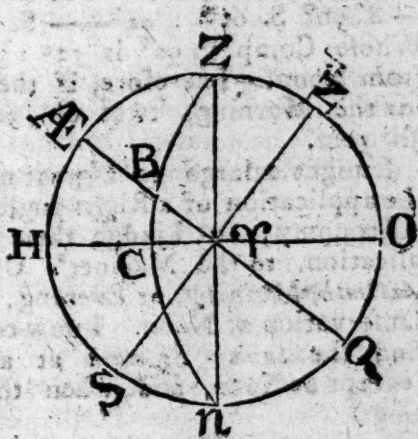
As S. C. $\odot$ Decl. $\dots$ S. C. $\odot$ Alt. $\dots$ S. C. Hour;
— S. $66^\circ : 30'$ — S. 90 . — S. $46^\circ : 4'$ — S. $37 : 15'$
Or, 1h. $49' : 40''$ from 6 : A.M. or P.M.

Prob. 17. The Sun in the Equinoctial, the Lat. of the Place (suppose $51^\circ \frac{1}{2}$ N.) and Hour of the Day, (admit $3h \frac{1}{2}$ Afternoon, or $8h \frac{1}{2}$ in the Morning, each of which are $3h \frac{1}{2}$ distant from the Meridian or Noon) given, to find the Sun's Height and Azimuth.

Construction.

1. $3h \frac{1}{2}$ from 6h. rests
2h. $\frac{1}{2}$ from 6 a Clock,
(or the Center Υ)
which reduced into
Deg. and Min. is $= 37^\circ 30'$.

2. Then the Circle drawn, quarter'd, and noted with Z n, and H O, and the Axis NS and Equinoctial EQ also drawn by the help of Lat. $51^\circ : 30' N$. ($\mathcal{A}$. represents Noon, and Q Midnight.)



3. Make $\Upsilon B = \frac{1}{2}$ Tang. $37^\circ 30'$ the Hour from 6. Lastly, describe through the Points Z B n, the Azimuth Circle Z B C n. Then in the Right-angled Triangle, $\Upsilon C B$, Right-angled at C, is given the $\angle C \Upsilon B$, the Comp. Lat. $38^\circ : 30'$, to find the Sun's Altitude CB, and Azimuth ΥC . Therefore it will be by Logar. pr. Rule of opposite Sides and Angles.

M

As

As $R :: S. \text{ hor. from } 6 :: S. C. \text{ Lat. } S. \odot \text{ Alt.}$
 $— S. 90^{\circ} S. 37^{\circ} : 30' — S. 38^{\circ} : 30' — S. 22^{\circ} : 16'$

And again,

As $T. C. \text{ hor. } R :: S. \text{ Lat. } T. \odot \text{ Azim.}$
 $— T. 51^{\circ} 30' — S. 90^{\circ} — 51^{\circ} : 30' — T. 30^{\circ} : 59'$
 which added to $90^{\circ} = T. O$, gives the *Azimuth* from the North, to be counted Easterly, if it be in the Morning; but Westerly, if it be in the Afternoon. But subtracted from $90 = T. H$ gives the *Azimuth* from the South, to be counted towards the West, if it be in the Afternoon; but if it be in the Morning, towards the East.

Prob. 18. If in the same Triangle $T. C. B$, were given the Sun's *Altitude*, when he is on the Equinoctial ($22^{\circ} : 16'$) and his *Azimuth* ($30^{\circ} : 59'$ from the East or West) to find the Hour of the Day, and Lat. of the Place?

The Proportions by Logar. are,

As $T. \odot \text{ Alt. } R :: S. \odot \text{ Azim. } T. \text{ Lat.}$
 $— T. 22^{\circ} : 16' — S. 90^{\circ} S. 30^{\circ} : 59' T. 51^{\circ} : 30' N.$

And,

As $R :: S. C. \odot \text{ Alt. } : S. C. \odot \text{ Azim. } S. C. \text{ hour.}$
 $— S. 90^{\circ} S. 67^{\circ} : 44' — S. 59^{\circ} : 4' — S. 37^{\circ} : 30'$
 Whose Comp. to 90° is $52^{\circ} : 30'$. Or in Time 3h. 30m from Noon. Therefore, if the Observation was made in the Morning, 'twas 8h. 30'. if in the Afternoon, 3h. 30m.

I might enlarge to a great number of Questions, in the application of a Right angled spherical Triangle, to Astronomy; but I judge these sufficient, with due Application, to the Mariner's Use, in finding the Lat. or *Azimuth*, Morning, or Evening, when he cannot get an Observation at Noon. I now come to shew how he may find the Sun's *Azimuth* at any time of the Day, (except at Noon, and when the Sun is rising or setting.)

Prob. 19. Given the Lat. of the Ship or Place, $51^{\circ} : 30'$ North, the Sun's Declination ($23^{\circ} : 30'$ N.) and *Altitude*, or Height of the Sun ($49^{\circ} : 40'$) To find the Sun's *Azimuth* from the North or South?

from the South. Or H: measured the backward way of the half Tangents from 90° . counting 80° . 10° . and added to 70° . 20° . &c. gives the Sun's Azimuth from the South as before.

But to determine the just Quantity of the Sun's *Azimuth*, from the North or South by a Logarithmetick. Calculation, you must observe this Rule;

Add the Complements of your *Data* (given things) together, and find the Difference between their half Sum, and the Comp. of the Declination, if the Latitude and Declination are both North or both South; (but if the Latitude and Declination are one North, the other South, take the half Sum from the Declination added to 90°.)

Then to the Arithm. Comp. of the Logarithms

of the Sine of the Comp. of $\left\{ \begin{array}{l} \text{Lat.} \\ \text{Alt.} \end{array} \right\}$ add the

Logarithm Sines of the $\left\{ \begin{array}{l} \frac{1}{2} \text{ Sum} \\ \text{Diff.} \end{array} \right\}$ afore-found;

half the Sum of those four Logarithms gives the Sine-Comp. of half the Sun's Azimuth; from North in North Latitude, and from the South in South Latitude.

Operation.

To Comp. } Lat. 48 : 30 S. Co. Ar. — 0.205850
 } Alt. 40 : 20 S. Co. Ar. — 0.188939
 } Dec. 66 : 30 —————

$$\text{Sum} = 145 : 40 \text{ -----}$$

$\frac{1}{2}$ Sum = 72 : 40 — — — — S. 9.979815

$$\text{Co. De.} = 6 : 10 = \text{Diff.} \quad \text{S. } 9.031089$$

Sum 19.405693

 $\frac{1}{2}$ Sum 9.702846

Sing

Sin. Comp. = 59 : 42 ($\frac{1}{2}$ the Azim.

59 : 42

Sun's Azim. 119 : 24 from the North.

Subtract from 180 : 00

Sun's Azim. 60 : 36 from the South.

Which turn'd into Points of the Compass is $5\frac{1}{2}$

+ $1^{\circ} 32'$ so that the Sun is $\left\{ \begin{array}{l} \text{S. E. b. E. } \frac{1}{2} \text{ E. } 1^{\circ} 32' \text{ Ely.} \\ \text{S. W. b. W. } \frac{1}{4} \text{ W. } 1^{\circ} 32' \text{ Wly.} \end{array} \right.$

Or Morning

If the Observation was made in the Afternoon,

Note. The Comp. Arithmetic. of the two Log. Sines in this Example (or any other) is found by subtracting each Figure in the Tables from so many Nines, (or 9.999999) and setting down the Remainders.

Examp. 2. In the Lat. $51^{\circ} 30'$ S. the Sun's Declin. $23^{\circ} 30'$ S. and his Altitude $49^{\circ} 40'$ given to find his Azimuth from the South?

The Operation is the same with the first Example, only as the Azimuth there was accounted from the North, this finds it from the South Part of the Horizon, $119^{\circ} 24'$. Which taken from 180. remains $60^{\circ} 30'$ from the N. so that the Sun would then be N. E. b. E. $3^{\circ} 15'$ East A M. or Morning, and N. W. b. W. $3^{\circ} 15'$ W. if P. M. or Evening.

Examp. 3. In the Lat. $51^{\circ} 30'$ N. the Sun's Declinati- on $13^{\circ} 30'$ S. and his Alt. $19^{\circ} 40'$ what is the Sun's Azimuth from the South?

Operation.

To. Co. $\left\{ \begin{array}{l} \text{Lat. } 38 : 30 - \text{S. Co. Ar. } 0.10850 \\ \text{Alt. } 70 : 20 - \text{S. Co. Ar. } 0.026102 \end{array} \right.$

Dist. from N. Pole 103 : 30

Z = 212 : 10

Add $\left\{ \begin{array}{l} \frac{1}{2} \text{ Z} = 106 : 10 \text{ S. } 9.982477 \\ \text{Diff. } 2 : 40 \text{ S. } 8.667689 \end{array} \right.$

Z. 18.882118

S. C. is $73^{\circ} : 58'$ $\frac{1}{2}$ Z. 9.441059

M 3

Doubled

Doubled is $147^{\circ}.56'$. $\odot$ Azimuth from the N. And the $\odot$ Azimuth from the North subtracted from 180° . gives $32^{\circ}.04'$. the $\odot$ Azimuth from the South Easterly in the Morning, or South Westerly Afternoon; which is S. S. E. $9^{\circ}.34'$. E. A. M. or S. S. W. $9^{\circ}.34'$. W. P. M.

Exam. 4. In the Lat. $51^{\circ}.30'$. S. the $\odot$ Declin. $13^{\circ}.30'$. N. and his Alt. $19^{\circ}.40'$. what is the Sun's Azimuth?

Add the Declination to 90° . and it's $103^{\circ}.30'$. the Sun's Distance from the South Pole; then work as in the third Example, and you'll have the Sun's Azimuth from the South $147^{\circ}.56'$. (as before) which subtract from 180° . leaves the Sun's Azimuth from the North Eastward $32^{\circ}.04'$. or N. N. E. $9^{\circ}.34'$. East in the Morning, and N. N. W. $9^{\circ}.34'$. W. if the Observation had been in the Afternoon.

These are all the Varieties that can happen in finding the Sun's Azimuth.

Likewise the Sun's Azimuth may be found Logarithmic. at two Operations thus: Let it be as in the first Example, *viz.* Latitude $51^{\circ}.30'$. Sun's Declination $23^{\circ}.30'$. North, Alt. $49^{\circ}.40'$. to find the Sun's Azimuth, having made the same Preparation, as in the foregoing Examples, and found the Comp. Lat. $38^{\circ}. \frac{1}{2}$ Comp. Alt. $40^{\circ}.20'$. the Comp. Declin. $66^{\circ}.30'$. the half Sum $72^{\circ}.40'$. and Diff. $6^{\circ}.10'$. Then say,
As $R \propto S. C. Lat. :: S. C. Alt. \propto$ a 4th Sine
— $S. 90 - S. 38^{\circ}.30' - S. 40^{\circ}.20' - S. 23^{\circ}.46'$.

Again,

As 4th S. $\propto S. \frac{1}{2}$ Sum $::$ Diff. $\propto$ a 7th Sine.
— $S. 23^{\circ}.46' - S. 72^{\circ}.40' - S. 6^{\circ}.10' - 14^{\circ}.45'$
Whose Logarithm is ————— 9.40569
To which add Radius ————— 10.0000

Sum is 19.40569

$\frac{1}{2}$ Sum 9.70284

S. C. is $51^{\circ} : 42'$

Doubled $59 : 42$

Sum $119 : 24$ is the Sun's Azimuth from the North as in the first Example before found.

Instrumental by Gunter's Scale thus,

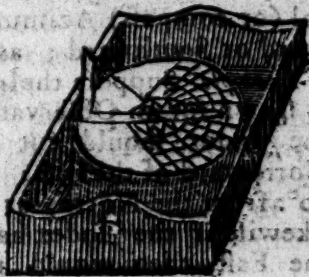
The Ext. $\left\{ \begin{array}{l} R. S. 90^{\circ}. \text{ to } S. C. \text{ Lat. } 38^{\circ}. \frac{1}{2} \text{ on Sines} \\ \text{reaches } S. C. \text{ Alt. } 40^{\circ}. 20'. \text{ to a 4th Sine } 23^{\circ}. 46'. \end{array} \right.$ on the Sines.

The Ext. $\left\{ \begin{array}{l} 4th S. 23^{\circ}. 46'. \text{ to } S. \frac{1}{2} Z. 72^{\circ}. 40'. \text{ on Sines} \\ \text{reaches } Diff. 6. 10'. \text{ to } S. 14^{\circ}. 45'. \text{ on the Sines;} \end{array} \right.$ against which underneath on the verfed Sines, stands $119^{\circ}. 24'$. the Sun's Azimuth from the North as above.

Having shewn how to work an Amplitude or an Azimuth in the preceding Problems, (which we call the Sun's true Amplitude or Azimuth, to distinguish it from the Magnerical, or that obtain'd by an Azimuth-Compass, that has Variation; proceed we therefore to shew the Use of the Sun's Amplitude-Compass, and thereby with the Sun's true Amplitude or Azimuth, (found by Calculation) to find the Variation of the Mariner's Compass.

1. The Use of the Azimuth-Compass.

THIS Compass differs from the Meridian or common Compass, in these few necessary Appendants or Things, *viz.* Upon the round Box, wherein are the Fly and Needle, is fastened a broad Circle of Brass, the half of the Limb thereof is divided into 90° . numbred from the Middle of the said Divisions both ways, with 10, 20, 30, &c. unto 45° . which Degrees are also subdivided into Minutes by Diagonal Lines, and by certain Eccentric Circles intersecting one another; for these Degrees are drawn from the opposite Part of the Limb whereon the Index moveth, cutting those Degrees. On this Index is erected a Sight, which for conveniency is to fall down with a Hinge, and set upon Occasion; and from the Top of this Sight, down to the Middle of the Index, is fastened a Thread or Lute-string, to shew the Shadow of the Sun, upon a Line that is on the Middle of the said Index.



And by this Means of placing the Index upon the Circumference, the Degrees come to be as large again as they would be, if it moved upon the Center, by *Euclid Lib. 3. Prop. 20.*

This broad Circle is crossed at right Angles with two Strings, and commonly from the Terminations of these Strings are drawn four small black Lines on the Inside of the Box, for rectifying the Instrument in time of Observation, by the four Lines that are also drawn at right Angles, on the Superficies of the Fly.

This Compass, being thus fitted, is hung in strong Brass Rings, and those also fastened in to a square Wainscot Box fitted for that Purpose. See the annexed Figure thereof.

1. To observe with this Instrument, do thus for an Azimuth; rectify the Brass Limb on the Edge of the Box (by the Needle and Fly within the Box) according as the Nature of the Observation doth require.

For if the Observation be in the Forenoon, then you must put the Center of the Index upon the West Point of the Chard or Fly within the Box; and so that the four Lines on the Edge of the Chard, and the four Lines by the Inside of the Box, do always concur.

The Instrument being thus rectified, turn the Index towards the Sun, until the Shadow of the Hypotheneusal Thread fall directly into the very Sight that is on the Index, and also upon a Line that is in the middle of the Index; then at the same time will the inner Edge of the Index cut the Degree and Minute of the Sun's Magnetical (or compass) Azimuth from the East to the Northward or Southward; as for

Example. Suppose the Instrument be Rectified, as before is shewn for an Observation in the Forenoon; and that the Index should cut 100° upon the Limb to the Northward of the East: then is the Azimuth of the Sun 80° from the North, or else 100° from the South. So likewise if the Index had cut 100° to the Southwards of the East, then would the Azimuth be 80° from the South, and 10° from the North.

N. B. That the Compass standing in this Position; and if the Azimuth of the Sun be less than 45° deg. from the Meridian, and you turn the Index towards the Sun, it will go off the Divisions on the Limb, and there can be no Use made thereof as it now stands.

There

Therefore you must turn the Instrument, just one Quadrant or Quarter of the Compass, viz. place the Center of the Index on the North or South Point of the Chard, according to the Sun's Position from you, and then the Edge thereof will cut the Degree of the Sun's Azimuth from the North or South.

That which is said as to the Use of the Azimuth Compass, when the Sun is on the East Side; the like is to be understood with the same Reason, when he is on the West Side of the Horizon.

2. To observe an Amplitude by the Azimuth Compass.

1. If you would take it in a Morning at Sun-Rising, turn the Center of the Index right over the West Point of the Fly, and rectify the Instrument by the Lines within the Box, to the Lines on the Fly.

Then looking through the Sight, turn the Index towards the Sun, until you cut the Body of the Sun with the Thread; at the same time will the edge of the Index shew the Degree of the magnetical Amplitude, upon the graduated Limb, from the East, either Northerly, or Southerly.

2. But if you take the Amplitude in the Evening at Sun-setting, then you must put the Center of the Index over the Point of the Fly, and proceed as before.

Cautions to be observ'd in taking the magnetical Azimuth and Amplitude.

1. 'Tis best to take the Azimuth when the Sun is not very high above the Horizon, because the Motion of the Sun is then more easily observed.

2. Because of the Refraction of the Vapors near the Horizon, which the Sun causes to appear in the Horizon, when indeed he is about 30 Minutes below it; therefore when you observe for the Amplitude, let the Center of the Sun be about 30m or near half his apparent Diameter 32m above the Horizon.

3. When you observe for the Azimuth, at that Instant to observe the Sun's Altitude with a Fore-staff, Quadrant, or Almucantar Staff, (whose Use shall be shewn a little farther)

4. To find at that Instant of Time you observe for the Azimuth or Amplitude exactly the Sun's Declin. and Lat. the Ship is in: As for Example.

Admit at Sea, September the 9th, 1732, my Ship was yesterday Noon in the Lat. of $45^{\circ} : 30'$ North per Account, the Sun's Declination was then, $1^{\circ} : 25'$ N. but having run South-westerly till the Morning 6 o' Clock, and made 45m Southing, I would know the Lat. of the Ship, and Sun's Declination, for that time? $45^{\circ} : 30' - 0 : 55 = 44^{\circ} : 45'$ N. the Lat. of the Ship;

Sept. the 8th } Sun's Declin. is { 1 : 25' } N.
9th } { 1 : 22' }

Diff. is the Diurnal Decrease of Declination, } 0 : 23

Then say,
hor. m. ho. m.

If 24 give 23, what 18, Time? Facit 17
which subtracted from $1^{\circ} : 25'$, the Sun's Declination
North decreasing, gives $1^{\circ} : 08'$ North, the Sun's Declina-
tion for the Hour given; (which is near upon the
time of Sun-rising.)

After the same manner, you may find the Lat. and Declination for any Hour from Noon; or at the Time you would observe for the Azimuth,

3. To find the Variation of the Compass, having the Sun's true Amplitude or Azimuth, obtain'd by Prob. 8th and 19th of Astronomy foregoing; and also the Magnetical Amplitude or Azimuth, gain'd by the Azimuth, Compass, and preceding Rule.

Definition.

The finding out the admirable Virtue of the *Loadstone* on a Needle touch'd thereon, doth point to a meridional Polition, and was the greatest Advantage to *Navigation* that ever happened; yet in this useful *Arcanum* there is this Defect (from secret Causes I have not room here to speak of) that the Needle, tho' well touch'd in the Mariner's Compass by the Magnet, yet admits of several Variations in different Places, Easterly or Westerly, more or less, to above 30 Degrees, which the Mariner should carefully observe at all Seasons, or he may bring his Ship to he knows not where.

Therefore to proceed :

The Variation of the Compass, in plain Terms, is nothing else but the Difference Easterly, or Westerly: that the North Point of the Sea Compass declines, or varies from the true (North, or) Meridian of the (ter-
raqueous Globe or) World; and may be found by the following Rules and Examples.

Rule 1.

When the Compass, Amplitude, or Azimuth, and the Sun's true Amplitude, or

Azimuth, are { the } same,
 { not the }

There's no } Variation.
Their Difference is the }

Rule 2.

For the Quantity of Variation,

Amplitudes, or } of { one } Kinds;
Azimuths } { Diff. }

Their { Diff. } is the Variation.
 Sum

If the Sum exceed 90° , subtract it from 180° .

Rule

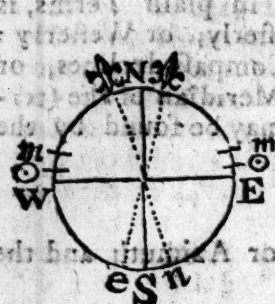
For the Quality of the Variation.

If true Ampt. pr } Right } of the magnetical,
Azim. be to the } Left }

The Variation is $\left\{ \begin{array}{l} \text{East.} \\ \text{West.} \end{array} \right.$

Examp. 1. Being at Sea Sept. the 9th, 1732, in the Lat. of $44^{\circ} : 45'$ N. the Sun's Declination $1^{\circ} : 08'$ N. by Calculation, the Sun's Amplitude was $01^{\circ} : 35'$ East-northerly; but observing by the Azimuth Compass at Sun-rising, found the Magnet. Ampl. E. $10^{\circ} : 50'$ N. I demand the Variation?





1. Geometrical.

Construct. 1. Describe a Circle with a Chord of 60° quarter it, and note it with N. North, S. South, W. West, E. the East Points of the true Horizon.

2. Make $E \odot =$ Chord of the Sun's true, and $E m$, the magnetick Amplitude, so shall $\odot m$ on the Chords be $= 9^\circ : 15'$, the

Variation in Quantity,

3. Extend your Compasses from m , the magnetical Amplitude (or Azim.) to N, the true North; that Extent shall reach (on the Circle) from the Sun's true Amplitude (or Azim.) $\odot$ to the false, or Compass North N, $\times = \odot m = 9^\circ : 15'$ Easterly.

2. Arithmetical.

From the Sun's magnetick Amp. $E. 10^\circ : 50' N.$
Take the Sun's true Amplitude $E. 01 : 35 N.$

Remains the Variation $N. 09 : 15'$
Easterly.

Examp. 2. At Sun-setting, in the same Scheme, let the magnetick Amplitude be $W. 10^\circ : 50' N.$
And Sun's true Amplitude $W. 01 : 35 N.$

Their Difference is the Variation $N. 09 : 15'$
Westerly.

Examp. 3. At Sun-rising, let the Sun's Amplitude be East $10^\circ : 10'$ North, and by the Azimuth Compass East $10^\circ : 10'$ South; What's the Quantity and Quality of the Variation?



To the Sun's Amp. $E. 10^\circ : 10' N.$
Add the magnet. $E. 10 : 10 S.$
Sum is the Var. $W. 20 : 20$

Examp. 4. Let the Sun's Azim. in the Mo. be $N. 79^\circ : 50' E.$
And the magnet. $S. 79 : 50 E.$

Sum $159 : 40$

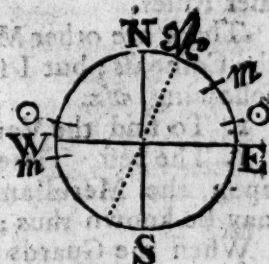
Subtract from $NES = 180 : 00$

Remains the Variation West $20 : 20$

as in the Scheme above. Observe, that the Azimuths are accounted from North and South, Easterly, or Westerly; as the Amplitudes were counted from the East or West, Northerly, or Southerly.

Examp. 5. At Sun-setting, let the Sun's Ampl. be W. $10^{\circ} : 10' N.$ and the mag. Amp. W. $10^{\circ} : 10' S.$ What's the Variation?

Sun's Amplit. W. $10^{\circ} : 10' N.$
Magnetical. W. $10 : 10 S.$



Their Sum is }
the Variat. } $20 : 20$ Easterly.

Example. 6. in the same Scheme.

The Sun's Azim. in the Even. N. $79^{\circ} : 50'$ W.
Magnetical Azim. _____ S. $79 : 50$ W.

Sum $159 : 40$

Subtract from $180 : 00$

Variation Easterly $20 : 20$

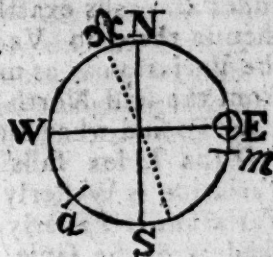
Examp. 7. In the same Scheme.

The Sun's Azim. in the Morn. N. $79^{\circ} : 50' E.$
Magnetical _____ N. $59 : 30 E.$

Diff. is the Variation Easterly, $20 : 20$

Examp. 8. The Sun in the Equinoctial rises East, and sets West in all Parts of the World, (which is about the 10th of March, and 12th of September) at which time you observe by your magnetical Compass, he rises East by South. What is the Variation?

The Sun being at E, in the East Point of the Horizon, and the magnetick Amplitude at *m*, E. by S. by Construction the 1st. the false North of the Compass will be found one Point to the Westward of the true North N. So that the Variation is 1 Point, or $11^{\circ} : 15'$ West.



Again;

Again ; the Sun in the Equinoctial rises E. by N. the Variation is 1 Point Easterly. If he sets W. by N. the Variation is 1 Point Westerly : If W. by S. 1 Point Easterly ; as will plainly appear, if you project by the former Rules.

There are other Methods of finding the Variation of the Compass ; but I shall briefly mention but these three following, *viz.*

1. To find the Variation by the North Star.

1. The best Time for this is, when the North Star is upon the Meridian, above or under the Pole ; which may be known thus ;

When the Guards or Pointers of the Great Bear are right under the North Star, it is upon the Meridian, above the Pole ; but when the said Pointers are right over the North Star, it's upon the Meridian, under the Pole ; and this is easily known by holding up a Thread and Plummets exactly between your Zenith and the North Star ; the Thread will cut the two Stars call'd the Pointers.

2. Then to find the Variation with your Azimuth Compass ; look through the Sight and turn the Index towards the North-Star, until you cut the Star with the Thread, and at the same time the Edge of the Index will shew you the true North ; and as many Degrees as you find the Index on the East-side of the *Flower-de-luce*, or North Point of your Compass, so many Deg. is the Variation Westerly ; or as many Deg. as the Index is distant from the *Flower-de-luce* Westward, so many Degrees is the Variation Easterly : This is so plain, it needs no Example.

4. To find the Variation at Noon, by the Shadow of the Sun.

1. When by your Observation, you find the Sun on the Meridian, that is, at 12 at Noon, your Compass Index being turned towards the Sun, if the Shadow of the Thread fall upon the Line on the Index, and the Index also falls exactly upon the North and South Line, then is there no Variation ; but if it falls a-side of it, the Variation is as many Degrees as the Index is distant from the said North and South Line.

2. To find what Side the Variation is on.

If the Index falls on the East-side of the North, the Variation is Westerly ; but if on the West-side, then the Variation is Easterly ; for if the Beam of Sun, and the Shadow of the same Beam, make but one and the same
his

Right-line, it's plain, that the Sun being exactly South, his Shadow will be exactly North. But *Note*, That the Hour of 12, or Meridian Altitude of the Sun is known at Sea only by the greatest Altitude of the Sun that Day above the Horizon; and this might practically cause some Error; because about Noon, it's known by Experience, that one cannot for some time perceive that the Sun rises or falls, or be sensible that he changes Place, altho' it is certain he doth. Wherefore to observe more exactly, you are to mind how much the Shadow, all the time that the Sun seems to stand, changes Place upon your Compass, and to take the Middle betwixt the two Extreame, for the true meridional Line (or North and South) and trust to the Variation that it marks.

This also is so easy, that it needs no Example.

5. To find the Variation by two equal Altitudes of the Sun, taken before and after Noon;

1. With a Quadrant or Fore-staff, observe the Sun's Altitude, and the Point of the Compass he is on at that Moment of time, viz. about the Hours of 8, 9, 10, or 11, in the Forenoon.

2. Observe the Point of the Compass the Sun is upon, when he has the same Altitude (by your Quadrant or Fore-staff) in the Afternoon, that you noted down in the Morning (which will be about the same Hours distant from 12 o'clock in the Afternoon: Then, from these two Observations, may the Quality and Quantity of the Variation be found thus;

If these Points of the Compass be equally distant from the South-Point of the Compass, then there is no Variation.

2. But if the Point in the Forenoon be farther distant from the South-Point of the Compass, than the Point in the Afternoon, the Variation is Westerly.

3. If the Point in the Forenoon be less distant from the South-Point of the Compass, than the Point in the Afternoon, then is the Variation Easterly.

For the Quantity of the Variation,

Take the intercepted Arches between the South-Point of the Compass and these two Points, the one in the Forenoon, and the other in the Afternoon, found by Observation, the lesser of these two Arches being subtracted from the greater $\frac{1}{2}$, the Remainder is the Variation of the Compass requir'd.

Example

Example.

Suppose in the Forenoon at 9 o' Clock, I set the Sun by the (Azimuth) Compass and find the Sun bears E. S. E. and the Altitude 40° , and again in the Afternoon, about 2 o' Clock, I observe again the Point of the Compass the Sun is on when he hath the same Altitude (of 40°) which let us suppose is S. W. Then, in the last Scheme, let the Forenoon Point be *m*, and the Afternoon Point *a*, to find the Variation.

$$\begin{array}{rcl}
 \text{From S } m, \text{ E S E, 6 Points,} & \text{---} & = 67^{\circ} : 30' \\
 \text{Take S } a, \text{ S. W. 4 Points,} & \text{---} & = 45 : 00 \\
 \hline
 \text{The Diff. is 2 Points} & \text{---} & = 22 : 30 \\
 \hline
 \frac{2}{2} \text{ the Diff is 1 Point} & \text{---} & = 11 : 15
 \end{array}$$

The Variation Westerly ; because the Forenoon is farther from the South than the Point in the Afternoon. Or thus ;

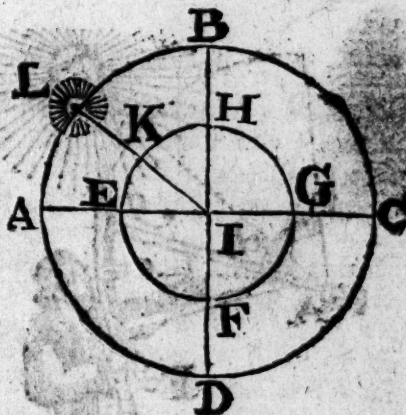
The Dist. between the E S E and S. W. is 10 Points, the half of which is 5 Points ; towards the S. W. it falls upon the S. by E. the Magnetical, or Compass South ; which is 1 Point to the Eastward of the true South : Therefore the Magnetical, or Compass North, is Westward from the true North 1 Point Westerly, being the opposite Point thereto.

Thus have we exhibited five Methods of finding the Magnetical Variation at Sea. I proceed now to speak of Celestial Observations by Instruments.

Definition. A Celestial Observation is founded on these two Principles, *Viz.*

I. That when many Circles are Concentric ; that is, when many Circles are drawn from one and the same Center, but of different Diameters, Lines drawn from their Center to their several Circumferences, divide each Circle in the same manner and Proportion.

As the Circles A B C D, E F G H, being described from the same Center I E A, and I K L drawn; the Arches E K, or K H, shall have the same Proportion to the Circumference E F G H, as the Arches A L, or L B, have to the Circumference A B C D.

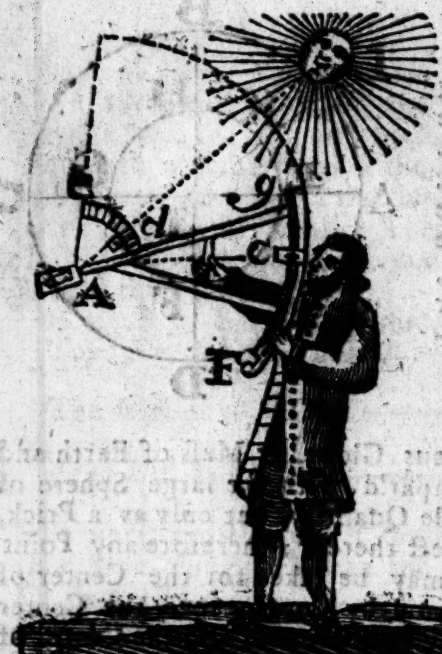


2. That the terraqueous Globe, or Mass of Earth and Water we live on, compar'd with the large Sphere of the Sun, is of no sensible Quantity, but only as a Prick, or meer Point, in respect thereof; therefore any Point on the Earth's Surface may be taken for the Center of the Sun, or Heavens; and by Consequence, the Center of every Instrument may be accounted also the Center of the Sun, or Heavens.



The Use of the Sea-Quadrant.

THIS Instrument was invented by Captain Davis, and thence called *Davis's Quadrant*; and by the French, the *English Quadrant*: it's at present the most general approved Instrument at Sea for observing the Sun's Meridian Altitude, or its Complement, the Zenith-Distance by the Noon-Shadow of the Sun.



You see in the prefixed Figure it consists of two Arches; the lesser Arch *d* contains 65 Deg. the greater *Fg*, 25 Deg. making together 90 Deg. from whence 'tis call'd a Quadrant. The lesser Arch is of a small Radius, being so designed that the Shadow-Vane *d*, used on it, being at so small Distance from the Horizon-Vane *A*, on which its Shadow (in Time of Observation) is to fall, might be more visible to the

Eye of the Observer. The greater Arch *Fg* is of a large (generally three times the) Radius, that it might contain the lesser Divisions of a Deg. and being of a competent Breadth, thereon are usually describ'd 10 concentrick Circles, intersected with 3 or 6 Diagonal Lines in each Degree, making each Intersection 2 or 1 Minutes. The Horizon-Vane *A* respects the Horizon; that at *d*, which gives the Shadow, is called the Shade-Vane; and that, through which you are to look for both Shadow and Horizon, is termed the Sight-Vane; as *C*.

Note, Of late there are two Shade-Vanes; one, in which is fixed a Lens or double Convex-Glass, which contracts the Sun's Rays, and casts them into a small bright Spot on a little black Spot on the Horizon-Vane, which has much improv'd the Instrument, if the Glass be well and truly fix'd; for with this it may be used in hazy Weather; also in clear Weather the Spot is more refin'd and conspicuous than the Shadow, which at best is not terminated. Also, when you use this Vane you have no need to allow 16 Minutes, the Sun's apparent Semidiameter, as you ought in the other Shade-Vane, which takes the Shade from the upper Limb of the Sun: This was the Contrivance of that ingenious Astronomer Mr. Flamsteed.

To Observe with this Quadrant.

1. Put the Horizon-Vane on the End at A, and home to the Center; the Sight-Vane on the Arch Fg, close to the Back of it, and the Shade-Vane on the little Arch de, to a Number of Degrees less than you judge the Zenith Dist. by 15 or 20 Degrees.

2. The Vanes thus fixed, turning your Back towards the Sun, the End CF in your Hand, look through the Sight-Vane, causing the upper Edge of the Shadow of the Shade-Vane to lie upon the upper Edge of the Slit in the Horizon-Vane, (or, if you use the Glass-Vane, bring the bright Spot on the black Spot on the Horizon-Vane) at the same time, if the Horizon appear through the said Slit in the Horizon-Vane, the Vanes of the Quadrant stand at the Sun's present Zenith Distance.

3. But if the Sky appear instead of the Horizon, slide the Sight-Vane a little higher towards g: On the contrary, if the Sea appear instead of the Horizon, then slide the Sight-Vane lower towards F; continue so to do till the Horizon appear thro' the Horizon-Vane.

4. Continue observing a little before Noon, and as the Sun rises higher, the Sea will appear thro' the Horizon-Vane, and the Sight-Vane must be slid lower accordingly, observing as often as may be convenient, till the Sun is at the highest, and then he will seem to stand.

5. When the Sun is past the Meridian, he begins to descend, or fall, and the Sky will appear thro' the Horizon-Vane instead of the Horizon: Then desist observing for that Day.

6. Having thus done, add the Degrees the upper Edge of the Shade-Vane standeth at, to the Degrees and Minutes cut by the Inside of the Sight-Vane; their Sum is the Complement of the Sun's Meridian Altitude, or Zenith Distance; which with the Sum or Diff. of the Sun's Declination for that Day, you may find the Height of the Pole or Latitude, as shall be shewn a little farther.

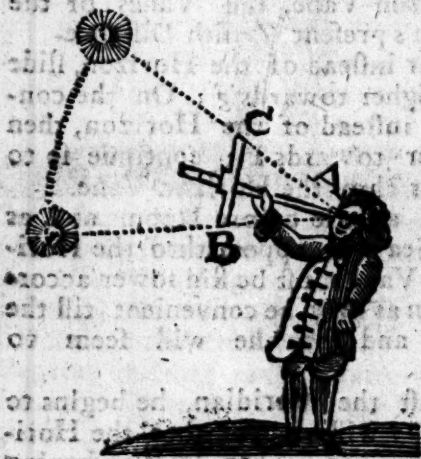
The Almancantar - Staff is made of Box or Pear-Tree : With an Arch of 15 Degrees curiously divided ; and with 3 Vanes, as a Quadrant is, to take an Observation of the Sun, a little after Sun-rising or setting, in order to find the Sun's Azimuth, and consequently the Variation of the Compass.



See the Figure prefixed ; its Use is very plain to them that can observe with the Sea-Quadrant.

The Description and Use of the Fore-staff and Cross-staff.

The Fore-staff is so called from the Posture of the Observer in using it, whose



Face is towards the (Sun, or) Star generally : Tho' for the Sun, it is so contrived (for preserving the Eye) to be used backward. It is called also a Cross-staff, from its Form ; being a square Staff with three or four Pieces of Wood a-cross it, which are called Crosses. The Staff is usually 2 and a half or 3 Foot long, and more than half an Inch

square, having four sides, each graduated like a Scale of Tangents : To each of them belong a distinct Cross, with that of the Horizon-Vane or Ten-Cross. The others are the 30, 60, and 90 Cross ; and are thus to be understood : The

	Deg.		Deg.
10 } Cross belongs	3	10	and ending at
30 } to that side	10	30	
60 } beginning	20	60	
90 } at	20	90	

The Use of the Fore-Staff, in taking the Sun's or Star's Meridian Altitude, or Zenith-Distance.

1. Observe, the 10. 30. 60. and 90 Cross is to be used according as you judge the Meridian Altitude is more or less; that is, if less than 10, use the 10 Cross: If between 10° and 30°, use the 30 Cross: If between 30 and 60, the 60 Cross: If more than 60, use the 90 Cross.

2. Put on the Cross suitable to your Observation, the flat Side of it towards the flat End of the Staff. Then,

3. Hold the flat End of the Staff (as A) to the corner of your Eye; there let it rest upon your Eye-bone, as near the corner of your Eye as you can, so it doth not hinder your Sight.

4. Then look at the upper End of the Cross, (as at C) for the Sun, or Star; and at the lower End of the Cross (as at B) for the Horizon.

5. If at the lower End of the Cross, you see all the Sky and no Water; then draw the Cross a little nearer to your Eye.

6. If on the contrary, you see all Water and no Sky, then slide the Cross a little farther from you.

7. Then if you see the Center of the Sun or Star, at the upper End of the Cross, and the Horizon at the lower End, then the Cross stands as it ought.

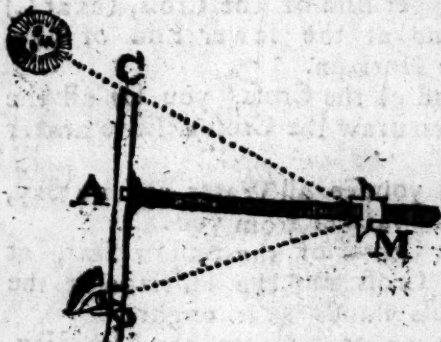
8. Wait till the Sun or Star be on the Meridian, making Observation often; and as the Sun or Star riseth, draw the Cross a little nearer your Eye.

9. If the Sun or Star be fallen, you will not see the Horizon (for the Water will hide it from you) and then your Observation is over at that time: stir not the Cross out of its Place; only see at what Degree and Minute it resteth, on that side of the Staff belonging to the Cross; and it's the Altitude or Complement thereof, viz. The Zenith Dist. according to the Word Alt. or Comp. on the Staff. Thus for a forward Observation. But what is more usual and convenient, is a backward Observation with the Fore-staff, which is of Use only with the Sun; and for this purpose the 10 Cross hath another piece of Wood or Ivory put cross it; so that the lower Edge of this cross Piece lieth even with the middle of the square Hole in the 10 Cross, which also answers to the middle of the Thickness of the Staff. There is also a Shoe, or Plate

of Brass or Tin, with a Hole or Slit in it, and so fitted, that it will slide off and fit the Ends of the 90, 60, or 30 Cross: These two Things prefix'd to a Fore-staff make it fit for a Backward Observation of the *Sun*, which is thus;

1. As before directed, according as you judge the *Sun's* Meridian Altitude is more or less, so use the 90°, 60°, or 30° Cross; putting it on the *Staff*, the flat side of it even with the flat End of the *Staff*; there screw it fast, and at the End of the Cross slip on the afore-said Brass Shoe, so as to leave a Slit-light through it, near the lower End of the Cross.

2. Put the Ten Cross (or Horizon-Vane) on the *Staff*, the flat side of it toward the other Cross at the *Staff's* End, and the cross Piece uppermost.



3. Turn your back to the *Sun*, look through the Slit in the Brass Shoe, at the lower End of the Cross, for the Shadow of the upper End of it, lying on the Ten Cross, in the Line answering the middle of the *Staff*, and on each side of the *Staff*.

4. At the same Time, the Horizon should be seen (through the afore-said Slit) to lie even with the Shadow on the middle Line in the Ten Cross, and at each End of it, on both Sides the Cross.

5. But if instead of the Horizon you see only Water there, then draw the Ten Cross nearer, till the Shadow and Horizon agree or meet in the said middle Line.

6. On the contrary, looking as before, if instead of the Horizon you see the Sky meet the Shadow, on the middle Line; then put the Ten Cross from you till you see the Horizon together meet at the middle Line.

7. Continue observing till the *Sun* be at the highest, and as the *Sun* riseth, you must draw the Ten-Cross nearer, in order to keep the Horizon and Shadow together on the middle Line of it.

8. IF

8. If the Sun be fallen (after you have continued observing as before directed) the Horizon will lie below the Shadow on the middle Line, then is the Observation finish'd at that Time: stir not the Ten Cross out of its Place; for where it now stands, (on that side of the Staff belonging to the Cross, at the End of it) is the Sun's Meridian Altitude, on its Complement the Zenith Distance, as before in observing forward. Next to

§. 7. Work an Observation by the Sun's Zenith Distance, taken with a Quadrant or Fore-staff, and the Sun's Declination for that Day given.

Definition. In whatsoever Part of the World you be, or whether the Sun's Declination be North or South; there are but four Cases or Varieties in working an Observation; which we shall explicate in their Order: But first shall demonstrate in the annexed Scheme.

The Latitude of a Place is the Distance between the Zenith and Equinoctial; that is, $NO = ZE$. The Sun's Distance from the Equinoctial, either to the Northward or Southward of it, and the Sun's Distance from the Zenith of the Place, is his Distance from your Vertical Point in that Place to the Northward or Southward of it. Now, if from $Z \odot$ the Sun's Zenith Distance, you subtract $E \odot$ the Sun's Declination, there remains $ZE = ON$ the Height of the Pole; or Latitude of the Place of Observation. Therefore,



Variety 1. Is, when the Sun is between the Equinoctial and Horizon, and then the Rule is as above; subtract the Declination from the Zenith Distance, the Remainder is the Latitude of the Place, contrary to the Declination,

Examples in North Latitude.

Admit at Sea October, 30th by Observation, (with a Quadrant or Fore-staff) I find the Sun to be distant from my Zenith $65^{\circ}. 15'$. towards the South, $17^{\circ}. 08'$. South. What Latitude is the Ship in?

From Sun's merid. Zenith Dist. Z $\odot$ 65 : 15 S.
 Subtr. the Sun's Declin. E $\odot$ ———— 17 : 08 S.
 Remains Lat. the Ship is in ———— 47 : 07 N.

Example 2. The Ship in South Latitude.

Let the Zenith Dist. be ———— 56 : 12 N.
 Sun's Declination ———— 23 : 17 N.
 Diff. is Lat. in ———— 32 : 55 S.

Variety 2. The Sun between the Equinoctial and the Zenith.

Example.



Suppose the Sun's Zenith Dist. to be 35° . South, and the Sun's Declination 10° . N. The Rule is; the Sum of the Zenith Dist. and Declination is the Lat. of the Place of the same Name with the Declination; for Z $\odot$ + $\odot$ E = Z E = O N. the Latitude North.

Arithmetical.

To the Sun's Zen. Dist. Z $\odot$ ———— 35 S.
 Add the Sun's Declin. E $\odot$ ———— 10 N.
 Sum is the Latitude required = Z E ———— 45 N.

Example 2. in South Latitude.

Sun's Zenith Dist. ———— 20 : 14 N.
 Declination ———— 19 : 52 S.
 Latitude in ———— 40 : 06 S.

Variety 3.

Variety 3. The Sun between the Zenith and elevated Pole, and then the Rule is; subtract the Zenith Dist. from the Declination, the Remainder is the Lat. of the same Name with the Declination.

[Example in North Lat.]

Suppose the Sun's Declination be $E \odot 20^{\circ} N.$ and his Zenith Dist. $Z \odot 10^{\circ} N.$ North. What is the Lat?

$Z \odot - E \odot = Z \odot = N. NPO,$ the Height of the Pole or Lat. North.



Arithmetical,

Sun's Declin. ————— $E \odot 20^{\circ} N.$
Zenith Dist. ————— $Z \odot 10^{\circ} N.$

Diff. is the Latitude required — $NPO, 10^{\circ} N.$

Example. 2. In South Latitude.

Sun's Declination ————— $22 : 30^{\circ} S.$
Zenith Distance ————— $12 : 15^{\circ} S.$
Latitude of the Place ————— $10 : 15^{\circ} S.$

Variety 4. The Sun between the elevated Pole and the Horizon (that is, when the Sun or Star comes to the Meridian below the Pole) the Rule is; subtract the Comp. of the Sun's Declination from the Zenith Dist. the Remainder is the Comp. of the Latitude.

Or thus

Add the Zenith Dist to the Declination, and subtract that Sum from 180° ; the Remainder is the Latitude, of the same Name with the Declination.



Ad.



Admit in a Ship at Sea on the Coast of Greenland, I observe the Sun's meridional Zenith Dist. (at Midnight) to be $79^{\circ} 50'$ North, the Sun's Declination being $20^{\circ} 40'$ North, I demand the Latitude the Ship is in?

$N P \odot - Z \odot = \odot Z N P$
Comp. Lat.

Arithmetical.

From — Co. Declin. — $N^{\circ} P \odot 69^{\circ} : 20'$
Subtract Zenith Dist. $Z \odot 79 : 50$

Remains Co. Lat. — $10 : 30$
Subtract from — $90 : 00$
Lat. of the Ship $79 : 30 N^{\circ}$

Or, thus;

To the Zen. Dist. $Z \odot 79 : 50$
Add the Declin. — $Q \odot 20 : 40$

Sum = $100 : 30$
Subtract from $180 : 00$

Remains the Lat. $79 : 30 N$.

Examp. 2. Of Stars near the North or South Poles, that never rise nor set in high Latitudes, (and come to the Meridian twice in 24 Hours.)

A Star's Zenith Dist. is — $42^{\circ} : 14' N^{\circ}$
And his Declin. — $17^{\circ} : 46' N^{\circ}$

I demand the Lat. of the Place?



* Zenith Dist. $42^{\circ} : 14' N^{\circ}$
* Declin. $87 : 46 N^{\circ}$

Sum $130 : 00$
Subtract from $180 : 00$

Lat. of the Place $50 : 00 N^{\circ}$

Variety 50

Variety. 5. If the Sun or Stars have no Declination (that is, if they are on the Equinoctial) the Zenith Dist. is the Lat. contrary to its Name.

Example.

A Ship at Sea March 10th, or Sept 12th, observes the Sun on the Meridian to the Southward of the Zenith 0° . What is her Lat?

From the Zen. Dist. $50 : N.$
Subtract the Declin. $00 : S.$



Ex. Zenith Dist. $50^{\circ} : N.$
The Lat. is $50 : S.$

Variety 6th. If the Sun or Star be in the Zenith, (that is, directly over your Head) the Declination is the Lat. and of the same Name with the Declination.



Example.

A Ship at Sea June 30th, between the Tropicks, observes the Sun in the Zenith.

The Sun's Declination being then $22^{\circ} : 12' N.$
The Latitude the Ship is in, is also $22^{\circ} : 12' N.$
As is plain from the annex'd Scheme.

Examp. 2. The Sun in the Zenith, and his Declin. $15^{\circ} : 30' S^{\circ}$.

Examp. 3. Suppose I were at Sea and observe the Sun's Zenith Dist. $20 : 57' N^{\circ}$. and the Declin. be also $20^{\circ} : 57' North$.

From Zenith Dist. —————	20 : 57	Nº.
Take the Declin. —————	20 : 57	Nº.
Remains Lat. —————	00 : 00	Nº.

So that the Ship is under the Equinoctial.

I have omitted the Projections of the foregoing Schemes, since they are so very easy to protract; for having with a Chord of 60 describ'd a Circle, and cross it at Right-angles with Zenith, Nadir and Horizon,

2. Set off the Sun's Zenith Dist from Z, towards H, if it be Southward, or from Z toward O, if Northward.

3. If the Sun or Star hath North Declin. the Equinoctial must be set off to the Southward of the Sun: And if the Sun hath South Declination, it must be placed to the Northward of the Sun.

4. The Equinoctial being thus Found, draw thro' the Center of the Circle the Equinoctial E Q, and cross it at Right-angles, with the Axis N S. then if you find the North Pole in your Figure above the Horizon Line H O, you are in North Latitude: If the South Pole be above it, your are in South Latitude.

N. B. The foregoing Rule will serve to find the Lat. by any of the known fixed Stars, if you work with the Comp. of any known Star's Altitude, or its Zenith Dist. observ'd with a Fore-staff when that Star is on the Meridian. To find which we come now to shew by our Tables.

Having look'd the Right Ascension of both the Star and Sun in their proper Tables, subtract the Right Ascension of the Sun from the Right Ascension of the Star: But if the Star's Right Ascension be less than the Sun's, (so that you cannot subtract, because the Sun and the Star are on contrary Sides of the first Point of Aries,) Add thereto 24 Hours, and then subtract, and the Remainder, if under 12 Hours, is the Time of that Star's coming on the Meridian Afternoon; but if the Remainder be more than 12 Hours, subtract 12 Hours from it, and the Remainder is the Time after Midnight.

Or thus;

To the Comp. of the Sun's Right Ascension, add the Right Ascension of the Star; the Sum is the Time of that Star's Southing. If the Sum exceed 12 or 24 Hours, take 12 or 24 Hours from it, and the Remainder is the Star's Southing.

Example.

On December 1, 1732, I demand at what Time the Bull's South Eye Aldebaran comes to (the South) or on the Meridian?

	h.	m.
Right Ascension Bull's Eye	4	17
Add	24	00
Sum.	28	17
Sun's Right Ascension	17	15 Sub.
Bull's Eye South at Night	11	02

Or thus;

	h.	m.
To the Comp. ☉ Right Ascen.	6	45
Add the Right Ascen. of the *	4	17
It gives as before	11	02

Example. 2.

To find at any time what Star is then upon the Meridian.

To the Sun's Right Ascension add the Time from Noon given, and the Sum is the Right Ascension of that Point of Heaven, that will come to the Meridian at the proposed Time; with which enter the Table of the Star's Right Ascension, and see what Star hath such Right Ascension, or nearest thereto, and that is the Star sought for.

Example.

November 6th, 1732, let it be requir'd to know what Star will be upon the Meridian at 12 a Clock at Night?

Sun's

Sun's Right Ascension ——— 15 : 27
The Time from Noon ——— 12 : 00

Sum 27 : 27
Reject. 24 : 00

Star's Right Ascension ——— 3 : 27

The Star that is nearest in Right Ascension, is the brightest of the Seven Stars or Pleiades, whose Right Ascension is 3h.: 28'.

5. VIII. Southing of remarkable Stars at Midnight through-
out the Year.

In January, none remarkable at Midnight; but the Bull's Eye comes to the Meridian Jan. 1, at 8h. 42m. Evening.

Jan.	day.		h. m.
{	5	Taurus ☉ or * Bull's Eye,	8-26
	10		8-04
	15		7-43
	20		7-23
	25		7-02
	30		6-42
		South at ———	
			in the Even.

Feb.	day.		h. m.
{	1	Bull's Eye South at	6-35
	5		6-19
	10		6-00
	15		5-41
	20		5-22
	25		5-04
			Evening.

Feb.	Day.		
{	3	* Lion's Heart.	} S°. at Mid-
	6	* Lion's Neck.	
	16	Lower of the two fore-	
		most.	
		* in ☐ of the great Bear.	night.

Mar.	Day.		
{	2	* Lion's Tail. ———	} at Midnight.
	3	* Lower of the two,	
	12	* Later in ☐ of the great Bear	
	21	* Upper of two later in ☐ of the	
	28	great,	
	29	* Last but two in grt. Bear's Tail,	
	* Virgin's Spike, ———		
	* Last but one in grt. Bear's Tail		

Apr.

Stars at Midnight.

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Apr. { 4 } * Last in great Bear's Tail,
 { 11 } * Dragon's Tail
 { 12 } * Arcturus in Bootes's Skirt.
 { 20 } * South Scale of Δ .
 { 26 } * Upper of two foremost in
 { 30 } $\square$ of little Bear, — — —
 * North Scale of Δ . } S°. at Midnight

May. { 3 } * Brightest in the Crown:
 { 5 } * Brightest in Serpent's Neck,
 { 9 } * Scorpion's Forehead.
 { 14 } * Scorpion's Heart. } South at Midnight

June 17th, * Brightest in the Harp on the Meridian at Midnight.

July. { 5 } * Brightest between the
 { 18 } Eagle's Shoulder. } S°. at Mid-
 * In the Swan's Tail. } night.

Aug. { 21 } * Fomalhaut.
 { 25 } * First, in Pegasus's Wing. } S°. at Midn.

Sept. { 11 } * Andromeda's Head.
 { 13 } * End of Pegasus's Wing.
 { 8 } Pole *.
 { 25 } S°. in Andromeda's Girdle. } S°. at Midnight

Sept. { 5 } * Bull's S°. Eye on the
 { 10 } Meridian, at
 { 16 }
 { 12 }
 { 28 } } h. m.
 { 4-58 }
 { 4-48 }
 { 4-36 }
 { 4-04 }
 { 3-42 }
 { 3-20 } in the Morning.

Oct. 11. Andromeda's southermost Foot on the Meridian at Midnight.

Oct. { 1 } * So. Eye of the Bull on
 { 10 } the Meridian at
 { 15 }
 { 20 }
 { 25 }
 { 30 } } h. m.
 { 3-9 }
 { 2-55 }
 { 2-36 }
 { 2-17 }
 { 1-57 }
 { 1-38 }
 { 1-18 } in the Morning.

Southing of the Principal

Nov.	16	* S ^o . Eye of the Bull.	} So. at Mid- night.
	25	* Capella, or the Goat	
	27	* Orion's left Foot.	
	29	* In the Bull's Horn.	

Nov.	2	} Bull's South Eye on the Meridian at	} h. m.	} Even. Morn.
	7			
	12			
	17			
	22			
	29			

Dec.	1	* First in Orion's Belt	} South at Midnight.
	3	* Last in Orion's Belt	
	5	* Orion's Right Shoulder.	
	7	* Auriga's Right Shoulder	
	13	* Foot of the great Dog, or Syrius	
	15	* Bright Foot of Π	
Dec.	18	* Mouth of the great Dog.	} South at Midnight.
	29	* Castor in Π	
	30	* Pollux in Π	

Dec.	2	} South Eye of the Bull on the Meridian, at	} h. m.	} In the Evening
	6			
	8			
	12			
	16			
	19			
	21			
	24			
	28			
	31			

To find the Latitude by the Stars.

To find the Height of the Pole or Lat. by the highest and lowest Meridian Altitude of the Stars (that doth not set) as in our Table, the great Bear, Northern Crown, &c. the Declination of the Star being also given.

Rule.—If you observe the highest Meridian Alt. of a Star when he is above the Pole; subtract the Comp. of that Star's Declination from its highest Meridian Altitude, and the Remainder is the Height of the Pole or Lat. you are in.

Example.

Example.

Admit that you observe the uppermost Star of the two foremost of the Square of the great Bear, and find its highest Meridian Altitude (by a Fore-staff) $59^{\circ} : 30'$; this Star's Declination being $63^{\circ} : 32'$ North, given to find the Lat.

Star's polar Dist. or Comp. Decl. ——— $26^{\circ} : 28'$

From Merid. Alt of the * subt. ——— $59 : 30$

Height of the Pole or Lat. N^o. ——— $33 : 02$

Example 2.

Admit I observe the abovesaid Star under the Pole, and find its lowest Merid. Alt. $6^{\circ} : 34'$ and its Declination as before. $63^{\circ} : 32'$ North, or its polar Dist. $26^{\circ} : 28'$. What Lat. am I in?

*'s polar Dist. ——— $26^{\circ} : 28'$

his Altitude, add ——— $6 : 34$

Lat. in ——— $33 : 02$ N^o.

To find the Lat. by the Stars that do not set; without their Declination or polar Dist.

Rule. If you observe the highest and lowest Meridian Altitude of a Star that doth not set, and add them together, half that Sum will be the Lat.

Examp. Admit you have not a Table of the Star's Declination, and yet would know by the Stars; having observ'd as before, the highest Meridian Alt. of a Star; suppose the upper of the two foremost in the Square of the great Bear, and find $59^{\circ} : 30'$; then 12 Hours after I observe the same Star on the Meridian below the Pole, and find its lowest Meridian Altitude $6^{\circ} : 34'$. I Demand the Lat?

Greatest } Merid. Alt. { $59^{\circ} : 30'$

Least } { $6 : 34$

Sum $66 : 04$

$\frac{1}{2}$ Sum is the Lat. ——— $33 : 02$ North.

The same is to be understood of any other Star that doth not set, as well in South Lat. as North.

Note. You should not alter your Parallel till both Observations be made; for it will cause some Error, (and so much the greater the further you are from the Parallel of your first Observation) when you observe the lowest Altitude of the Star.

To observe by the North (or Pole) Star.

This Star is called the Pole-Star, because it's the nearest to the North, or Arctick Pole; but is not in the said Pole, but about $2^{\circ} \frac{1}{2}$ distant from it, and hath been at a greater Distance; however 'twill be nearer and nearer, till the year 2100, when it will be less than 30 Min. from the Pole: But then after that will move farther and farther from it; so that in the Year 12700, (if the World last so long) it will be 48° from the said Pole, as some Authors have observed.

When the brightest of the Guards is	$\left. \begin{array}{l} \text{N}^{\circ}. \text{ subtr. } \{ 2^{\circ} : 4' \\ \text{W}^{\circ}. \text{ subtr. } \{ 1 : 10 \\ \text{S}^{\circ}. \text{ Add } \{ 2 : 4 \\ \text{E}^{\circ}. \text{ Add } \{ 1 : 10 \end{array} \right\}$	From the Pole-
		Star's Altitude,
		to the Pole Stars
		Alt. and the Sum
		or Difference is
		the Lat. or Height of the Pole.

And to know which of these Points the Guards are upon (from the North Star) imagine a Line drawn from your Zenith thro' the Pole-Star to the Horizon, and that shall be a Line of North and South, by which you shall know when the Guards are North or South; for when you perceive the brightest of the Guards exactly on that Line under the Pole-Star, (that is to say perpendicular under it) you may conclude, that the Guards are North; but when the brightest of the Guards is on the same Line perpendicularly above the Pole-Star, then are the Guards South. As for the other two Points, imagine likewise a Line of East and West drawn parallel to the Horizon, through the Pole-Star, (that is, cross, or at Right-angles, upon the Line of North and South;) and when you see the brightest of the Guards on that Line with the Pole-Star, and to the Right-hand, the Guards are East; if on the Left-hand, West; and then is the best time to make your Observation at the Pole-Star; *i. e.* when the Guards are either East or West.

Now to find the Lat. by the Pole-Star and Guards; wait till the brightest of the Guards be exactly upon one of the Points of the Compass, set down in your Table (that is to say, either East, West, North or South

South from the Pole-Star) for that is the best time to observe the Altitude of the North Star; to which, if you add or subtract what your Table sheweth, you shall have the Height of the Pole.

Example 1.

Admit that I observe the Altitude of the North Star to be $40^{\circ} : 30'$ above the Horizon, the Guards being then East from it; What is the Height of the Pole or Lat?

Alt. of the Pole-Star,	$40^{\circ} : 30'$	
Brightest of the Guards bearing	$1^{\circ} : 10'$	}
East; add;		
Height of the Pole or Lat. I	$41^{\circ} : 40' N^{\circ}$	
am in.		}

Observe that the Guards are East or West, when you find that the brightest of them is neither higher nor lower than the North-Star, which you may easily discover with your Cross-Staff or Quadrant, as soon as you have observed the Altitude of the North Star.

§. IX. The Description and Use of the Nocturnal.

1. The Nocturnal consists of three Parts; the first, term'd the unmoveable Part, is the broadest and greatest, on which is a Handle to hold it by in time of Observation, or using of it.

On the fore-side of which, in the outermost Circle, are the 12 Months, and each Month subdivided into its respective Days, or at least every two Days: They are counted towards the right Hand, mark'd with their Names, or the first three Letters thereof; as Jan. for January, Feb. for February, &c.

Within the Circle of Months, as a Circle divided into 24 Hours, and each divided into halves and quarters, on the backside of the Nocturnal, are the 32 Points of the Mariner's Compass, South uppermost, and East on the Left-hand: To each Point is set the Declination of the North Star, above or under the Pole which is known by und. for under, and abo. for above.



The *Nocturnals* are now made for both great and little *Bears*, having either two Circles of Months, marked G B, and L B; or two short Teeth or Indexes, proceeding from the second or middle Part of it, and marked G B, and L B, signifying great *Bear* and little *Bear*.

The third and moveable Part is called the Index; it is uppermost, on the foreside of the Instrument, having one Edge proceeding in a Right-line from the Center, which (in time of Observation) must be turned to the Guards: Through all 3 Pictes, in the Center of the Instrument, is a Hole, through which you are to see the North-Star when the Index is turned to the Guards.

The Use of the Nocturnal.

By it may be found the Hour of the Night, the Bearing of the Guards, and the Declination of the North-Star from the Pole; by which may be found the Latitude of the Place.

1. To find the Hour of the Night.

1. Place the Index of the second or middle Place, to the Day of the Month, where it's to be kept till the Observation is ended; then taking the Handle in your Hand with the foreside towards you,

2. And holding it upright (which you may discern when you do so, by the tip on the Top of the first or great Part of the *Nocturnal*) look thro' the Hole in the Center for the North-Star.

3. Turn that Edge of the long Index, which proceedeth from the Center of the Guards, seeing at the same time the North-Star thro' that Hole; then will the Index shew the Hour of the Night, on the second or middle Part.

2. To find the Bearing of the Guards either of the little or great *Bear*; that is, upon what Point of the Compass they are, and thereby the North-Star's Declination from the Pole and Lat. of the Place, having the Height of the North-Star taken with a Fore-staff also given:

Example.

December the 10th, at 6 of the Clock in the Morning, observing the Pointers or Guards of the great *Bear* by the Edge of the Index; I demand their Bearing, and Declination of the North-Star?

Right

Right against the Edge of the Index proceeding from the Center, and on the back-side of the *Nocturnal* is S. W. by S. the Point of the Compass required; And on the said Point of the Compass is $2^{\circ} : 33'$ und. signifying the North-Star, is then $2^{\circ} : 33'$ under the Pole. And at the same time observing with the Fore-staff, I find the Altitude of the North-Star to be $43^{\circ} : 30'$; I demand the Latitude of the Place of Observation?

To the Alt. of the North-Star	$43^{\circ} : 30'$
Add its Declin. from the Pole under	$2 : 33$

Sum is the Lat. required, $46 : 03$ N $^{\circ}$.

Example.

February the 14th, I observe (with the *Nocturnal*, the Index of the little *Bear* L B, set to the Day of the Month) at 7 a Clock in the Evening the Guards of the little *Bear*, by the Edge of the long Index; I demand their Bearing and Declination of the North-Star?

Seeing the North-Star through the Hole in the middle, and the Guards of the little *Bear* by the Center-edge of the long Index, and the Index cutting 7 of the Clock: Then on the back-side of the *Nocturnal*, and against the said Edge of the Index is N. E. the Point of their Bearing; and on the said Point is figured $0^{\circ} : 35'$ abo. which signifieth the North-Star is then 35 Min. above the Pole.

Admit at the same time I observe by the Fore-staff, and find the Altitude of the North-Star to be $46^{\circ} : 38'$; I demand the Latitude of the Place?

From the Alt. of the North-Star	$46^{\circ} : 38'$
Sub. its Declin. above the Pole	$00 : 35$

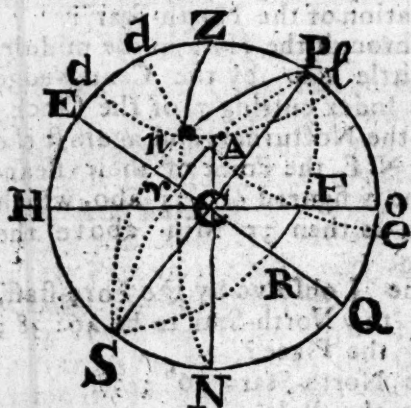
Remainder is the Lat. requir'd $46 : 03$

There are other Uses of the *Nocturnal*; as to find the Moon's Southing and High-water, but I judge that is better done by the Pen, as was directed in Page 5th, of *Coasting Navigation*.

CHAP. VI. Sect. I.

To find the Time of the rising and setting of the Stars, their Amplitude, Azimuths, Hour of the Night, &c.

APRIL 1. 1732, the brightest Star in the Crown comes to the Meridian 14^h after the Sun (or Afternoon) his Declination is $27^{\circ} : 51'$ North; I demand its Amplitude, Rising, and Setting, its Height, and the Time when it will be due East or West, the Hour of the Night, and Azimuth, (when the Altitude taken by the Fore-staff is 45°) in the Lat. of London, which is $51^{\circ} : 32'$ North?



In the adjacent Scheme Let P E S Q represent the Meridian, P S; the Axis, E Q; the Equinoctial; ZN, the Prime Vertical; H O, the Horizon, and d e the Parallel of any Star, as the brightest in the Crown's Course. If thro' the Poles P and S, and F, the Intersection of the Parallel d e, with the

Horizon, A, Meridian, or Hour Circle, P F S be drawn, in the Triangle C F R, is given the Angle at C, the Comp. Lat. $38^{\circ} : 28'$, and F R, the Star's Declination $27^{\circ} : 51'$ North, to find C F its Amplitude, and C R the Star's ascensional Difference, by Prob. 8 *Astronom. Prob.* foregoing, viz.

As S. C. Lat. .. R :: S. *'s Decl. .. S. *'s Ampl.
— S. $38^{\circ} : 30'$ S. 90 — S. $27^{\circ} : 51'$ — S. $48^{\circ} : 38'$.

Which being always the same way with the Declination, is therefore Northerly : So that the Star rises East $48^{\circ} : 38'$ Northerly.

2. For C R, the Star's Ascension x.

As

As R .. T. Lat. :: T. * Decl. .. S. * Asc. x.
 T. 45° — T. $51^{\circ} : 30'$ T. $27^{\circ} : 51'$ — S. $41^{\circ} : 36'$.

Which reduced into Time, is 2h. 43' : 44"; and this added to 6 Hours, because the Lat. and Declination are both North, gives the space of Time the Star required to pass from the Horizon to the Meridian. The Sum taken, therefore, from the Time that it passes the Meridian, shews the Time of its rising; but added, gives the Time of its setting.

April 1. 1732. The * given } h. ' "
 transits the Meridian at } 14 : 00 : 00
 x. Ascension + 6h. Sub. 5 : 43 : 44

Remainder is the Time 5 : 16 : 16
 of the given *'s rising in
 the Evening.

Again,
 To the Time of the said — } h.
 Star's coming to the Merid. } 14 : 00 : 00
 Add the same Time — 8 : 43 : 44

It gives the Time of — } 22 : 43 : 44
 the Star's setting } h.

From Noon; or at — 10 : 43 : 44
 in the Morning, rejecting 12
 Hours.

Thirdly,

From the same Data, and in the foregoing Figure, to find its Height, and the Time when the said Star will be due East or West.

Construction.

Through the Intersection of the Star's Parallel of Declination, with the Prime Vertical at A and P and S. describe another Hour-Circle or Meridian, as P A T S; then in the Right-angled spherical Triangle, C A T. are given the Angle at C, equal to the Lat. $51^{\circ} : 30'$ N. and A T, the Star's Declin. $27^{\circ} : 51'$ N $^{\circ}$. to find A C, its Altitude. and C T, the Time when it will be due East or West?

By Prob. 15: *Astronomic. Prob.*

As S. Lat. * Decl. : : R .. S * Alt. E. or W.
 — S. $51^{\circ} : 30'$ S. $27^{\circ} : 51'$ — S. 90° — S. $36^{\circ} : 39'$

Again.

As R .. T. C. Lat. : : T * Decl. .. S. of an Arch.
 — T. 45° T. $38^{\circ} : 30'$ T. $27^{\circ} : 51'$ — S. $24^{\circ} : 51'$

Whose Comp. $65^{\circ} : 30'$, converted into Time, is 4h. $20^{\circ} : 28''$. This subtracted from the Time of the Star's coming to the Meridian, gives the Time it will appear due East; but the said Arch of Time, added to the Time of its passing over the Meridian, shews the Time it will be due West.

Wherefore,

From the Time the Star is on the	}	h	'	"
Meridian, April 1. ———		14	: 00	: 00
Subt. the Arch last found		4	: 20	: 28

Time when * is due East,	9	: 39	: 32
--------------------------	---	------	------

Again.

The Star on the Meridian at ———	h	'	"
Add the said Arch ———	14	: 00	: 00
	4	: 20	: 28

It gives — 18 : 20 : 28

Reject 12

6 : 20 : 28

The Time the Star is due West in the Morning.

Fourthly.

The Altitude of the Star 45° . its Declination $27^{\circ} : 51'$ N. and the Lat. $51^{\circ} \frac{1}{2}$ N. given, as before; to find its Azimuth, and the Hour of the Night?

Construction.

In the former Scheme draw anl , parallel to the Horizon, at the Dist. of 45° , the Star's Altitude, through the Intersection of this, with the Parallel of Declination ane ; at n draw the Hour Circle PnS ; also the Vertical or Azimuth Circle ZnN : Then in the oblique spherical Triangle, ZPn , are given ZP , the Comp. of the Lat. $28^{\circ} : 30'$. Zn , the Comp. of the Star's Alt. $45'$ and Pn , the Comp. of its Declination $62^{\circ} :$

62° : 09'. To find the Angle $\angle Z P$, the *Star's* Azimuth, and the Angle $\angle Z P, \pi$, (the Hour from Noon): Wherefore, by the 19th *Astron. Prob.*

Preparation.

To the	}	Comp.	{	_____	38° : 30'
Add the				_____	45 : 00
				_____	62 : 09

Sum 145 : 39

From half the Sum _____ 72 : 49

Take the Comp. Declin. _____ 62 : 09

The Remainder call the Diff. 10 : 40

Then,

As $S. C. Lat. :: S. C. Alt. .. 4th Sine.$
 _____ $S. 90$ _____ $S. 38^{\circ} : 30'$ _____ $S. 45^{\circ}$ _____ $16^{\circ} : 07'$

As 4th. S. .. $S. \frac{1}{2} Z Sides :: S. \pi .. 7th Sine.$
 $S. 26^{\circ} : 07' - S. 72 : 49' - S. 10^{\circ} : 40' S. 23^{\circ} : 41'.$

Whose Logarithm is _____ 9.603913

Radius added is _____ 19.603913

$\frac{1}{2} :: S. C. 50^{\circ} : 40$ _____ 9.801956
 Doubled 50 : 40

Sum 101 : 2° the *Star's* Azimuth from the North at that Altitude.

For the Hour of the Night, 'twill be,

As $S. C. Decl. .. S. Azim. :: S. C. Alt. .. S. Arch.$
 _____ $S. 62^{\circ} : 09'$ _____ $S. 101^{\circ} : 20'$ _____ $S. 45^{\circ}$ _____ $S. 52^{\circ} : 57'$

the Angle $\angle Z P \pi$; which converted into Time, is 3h. : 33'. This subtracted from the *Star's* Southing 14h. (before found) gives the Hour of the Night (10h. 27') if the *Star* were on the East-side of the Meridian; but added to the time of Southing, gives 17h : 33' (or 5h. 33' after Midnight) the Hour of the Night, when the said *Star* is on the West-side of, or is past the Meridian.

Lastly; and generally, whatever has been done in relation

relation to the Sun, will hold good in the fixed Star's ; provided that in the room of the Sun's coming to the Meridian (which is every Day at Noon) be used that of the Star's Culminating, or Southing, which we have already shewn how to find.

§. 2. The Practical Questions in Astronomy solved by Inspection, by our Tables in a general Example, viz.

Sept. 14th, 1732. In the Lat. of 43 North, I demand the Sun's Declination, Amplitude, Rising and Setting; Length of the Day and Night; the Sun's Right Ascension, &c.

1. In Table of the Sun's Decl. look the Month September at Top, and the day of the Month in the Side Column, and in the common Angle of Meeting you have the Sun's Declination $0^{\circ} : 57'$ South.

2. After the same manner, in the Table $\odot$ Rt. Ascension, you'll find the Sun's Right Ascension Sept. the 14th, to be 12h : 6m, $12^{\circ} 7'$

3. To find the Sun's Amplitude, which is the Dist. of Rising or Setting of the Sun or Star, from the East or West Points of the Horizon.

Examp. 1. Let it be requir'd to find the Sun's Amplitude on the 20th of October. 1732, in the Lat. 43 N $^{\circ}$, the Sun's Declination for that Time is $14^{\circ} : 15'$ S $^{\circ}$. Therefore look for the Declin. 14° in the first Column of $\odot$'s Amplitude, and the Lat. 43 $^{\circ}$ at the Head of the Table on the Left-hand, and in the common Angle of Meeting is the Sun's Amplitude $19^{\circ} : 18'$ S. that is, the Sun rises E. $19^{\circ} 18'$ S. and sets W. $19^{\circ} : 18'$ S. for the Sun's Amplitude is always of the same Name with his Declination.

Examp. 2. The Lat. 43 $^{\circ}$ N $^{\circ}$. and Sun's Decl. Suppose $20^{\circ} : 25'$ North, what is his Amplitude? Because the Lat. and Declination are not even Deg. in the Table, we must take the proportional Part for the odd Minutes of the Sun's Declin. thus ;

$$\begin{array}{l} \text{Sun's Ampl. } \{ \text{for } \{ 20^{\circ}. \} \text{ Decl. is } \{ 27^{\circ} : 57' \\ \text{in Lat. } 43^{\circ}. \} \{ 21 \} \end{array}$$

$$\text{Subtr. and their Diff.} = 1 : 24 = 84 \text{ m.}$$

Then

Then say, by Proportion;
As $1^{\circ} = 60m. \dots 84' :: 25' \dots 35'$ prop. Part.

Then

Lat. 43° . Declin. 20° @ Amp. is $27^{\circ} : 53'$
To it add the prop. Part above $35'$

Gives Ampl. for Decl. $20^{\circ} : 25' = 28^{\circ} : 28' N.$

That is, the ☉ rises } E. $28^{\circ} : 28'$ North.
 } sets } W. $28^{\circ} : 28'$ North.

Example 3.

Let the Lat. be $43^{\circ} : 30' N.$ and Declination as in the last Example, $20^{\circ} : 25' N.$ What is the Sun's Amp?

For Lat. 43° . and Decl. $20^{\circ} : 00'$ } Amp.

the Amp. is $27^{\circ} : 58'$

For Lat. 43° and Decl. $21^{\circ} : 00'$ } $29 : 17$

Diff. as before $= 1 : 24$

As $70' \dots 84' :: 25' \dots 35'$ prop. Part.

And $27^{\circ} : 58' + 35' = 28^{\circ} : 28'$ the Sun's Amp.
for $20^{\circ} : 25'$ North Declin. in Lat. 43° North.

Again, Amp.

For Lat. 44° and Decl. $\left\{ \begin{smallmatrix} 20 \\ 21 \end{smallmatrix} \right\}$ $\left\{ \begin{smallmatrix} 28^{\circ} : 23' \\ 29 : 46 \end{smallmatrix} \right\}$

Their Diff. is $= 1 : 23$

As $60' : 83' :: 25' \dots 34'$ prop. Part.

And $28^{\circ} : 23' + 34' = 28^{\circ} : 57'$ the Sun's Amp. in Lat. 44° , with 20 Deg. $25'$ Declination.

Now, because the given Lat. $43^{\circ} : 30'$ is in the middle, between 43° and 44° , therefore the Medium of the Amplitudes before found is the Amplitude requir'd, Thus:

Lat. $\left\{ \begin{smallmatrix} 43 \\ 44 \end{smallmatrix} \right\}$ Decl. $20^{\circ} : 25'$. the Ampl. is $\left\{ \begin{smallmatrix} 28^{\circ} : 28' \\ 28 : 57' \end{smallmatrix} \right\}$

Sum $= 57 : 25$

half the Sum is the Ampl. requir'd, $28 : 42 N.$

Thus

Thus may the Amplitude be found for any odd Minutes of Lat. or Declination, tho' the Table is calculated for whole Degrees only.

Example 4.

In the Lat of 43° , the Sun's Declin. being $23\frac{1}{2}^{\circ}$ North, I demand the Time of the Sun's Rising and Setting, with the Length of the Day and Night?

Find the Lat. 43° at the Head of the Table (of the Sun's Rising and Setting) and the Degrees of the Sun's Declin. in the Left-hand Column, and in the common Angle of Meeting you have the Sun setting 7h. : 36m. because the Declination is North.

Sun-setting ————— 7h. : 36'
Subtract from ————— 12 : 00

Sun-rising is ————— 4 : 24

Sun-setting doubled ————— } h. m.
is the Length of the Day ————— } 15 : 12

Sun-rising doubled ————— } h. m.
is the Length of the Night ————— } 8 : 48

If there be odd Minutes of the Lat. or Declination, or both, you may find the proportional Part after the same manner as we exhibited in Example 2d and 3d of the Sun's Amplitude foregoing.

5. To find the Time of any Star's Rising and Setting, whose Declination exceeds not the Sun's, *Viz.* 23° : $30'$ by the abovesaid Table.

Example 1.

Decemb. 4th, 1732, I demand the Time of the Rising and Setting of the Bull's South Eye, or *Aldebaran*, whose Declination is 15° : $48'$ North, in the Lat. of 53° North?

Look in the left Side of the Table 16° (nearest to 15° : $48'$) of Declination, and the Lat. 43° in the Head thereof, and in the common Angle of Meeting you have the Star's semi-diurnal Arch, (or half the Time that Star doth continue above the Horizon in that Lat. or the Dist. of Time that Star is in going from the Horizon to the Meridian on the East-side: Likewise from the Meridian to the Horizon on the West-side of the Meridian. In this Case 7h. : 02m. Now, if you subtract these Hours and Minutes from the Time of the Star's coming

coming to the Meridian, (which will be found by the former Rules to be at) 10h. 48', the Remainder will be the Time of the Star's Rising; and if you add, the Sum will be the Time of the Star's Setting.

Operation.

	<i>h.</i>
The Time of the Star's Southing,	10 : 48
Its semi-diurnal Arch, subtract	7 : 02
Time of the Star's Rising in the Even.	3 : 46
Added is	17 : 50
Reject	12 : 00
Time of the Star's Setting in the Morn.	5 : 50

Note 1. If the Sum of the Addition exceed 12 Hours, cast away the 12 Hours.

2. And when you can't subtract, add 12 Hours to the Star's Southing, and then subtract; what remains, is its Setting.

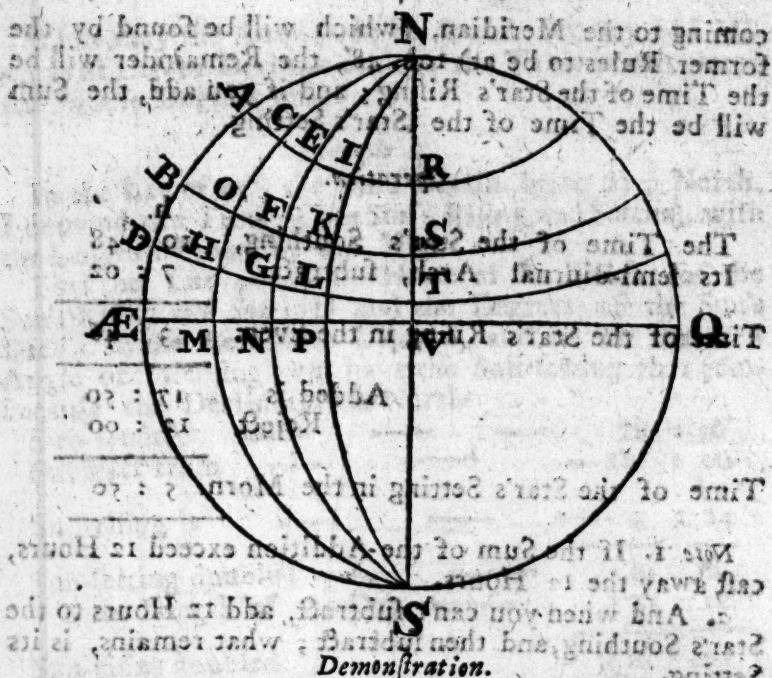
3. If you are in North Lat. and the Star hath South Declination, the Table gives the Star's semi-nocturnal Arch; which subtract from 12 Hours; the Remainder is the Star's semi-diurnal Arch, as before.

4. If you are in South Lat. and the Star hath North Declination, do the same as when you are in North Lat. and the Star hath South Declination.

Observation.

Since divers Young Navigators have been puzzled, to find that their whole Departure, or Meridian distance, doth disagree, considerable in their Outward and Homeward bound Voyage, we shall clear up, and Explicate this Point,

Demonstra-



Demonstration.
In the Prefixed Scheme let the Circles $N\&S$, NMS , NNS , and NPS be Meridians intersecting each other in N & S , the North and South Poles; and $ACEIR$, $BOFKS$, $DHGLT$, $EMNPV$ Arches of the Equator, or several Differences of Longitude made by the afore said Meridians with the Equator.

2. Then suppose a Ship sails from A East to C , then South to O ; it's plain, that AC is her Departure or Meridional Distance: But had she sailed from A to B to the South, and from B to O , it is evident that BO is her Meridional Distance: But BO is greater than AC , which was her Meridional Distance before, and consequently there may be as many Meridional Distances between the Places A and O , as it is possible to describe Parallels of Latitude between AC and BO , and all different from each other; but between A and O there is but one Difference of Longitude on the Equator, *viz.* EM ; and this Arch EM is not only the Difference of Longitude betwixt the Places A and O ; but it is also the Difference of Longitude between all the Places N & the Meridian NM : So that it's Obvious that if a Ship sails not homeward upon the same opposite Courses she went outward, her Meridional Distance will differ according to her different Courses, crossing different Meridians and Parallels.

Pra-



Practical Navigation.

PART III.



HAVING now gone thro' what I judge sufficient in the Theory of Navigation, I shall proceed to *Practical Navigation*; or the Application of the whole, in keeping of a Reckoning, or Sea-Journal; the careful Performance of which is not only the Mariner's Reputation, but (under God) the Conservation of Ship and all in it; the Ignorance whereof hath, no doubt, been the chief Cause of losing divers rich Ships, and many useful Subjects (of this Kingdom) and consequently thence the impoverishing of several Families.

Therefore they who take on them so great a Charge as the navigating Ships to remote Places, should make it their great Concern to be expert herein, when so great a Trust as Men's Lives and Estates are reposed in them; and not to think that the learning a few Problems only in the Theory (from such Teachers, who have learned to sail on the Shoar on a Slate or Paper only) will make a Man a compleat Artist; for Navigation is no trifling Knowledge, but a Science of the utmost Importance; because the Good both of the Publick and
Private

Private is in Danger from a very small Mistake committed therein, and therefore it should be learned to the utmost Perfection; and such Persons who are about to learn this Art, I advise they would apply themselves to a proper Master, *viz.* One who has Experience in the Practice, as well as Knowledge in the Theory only, by which means they may add to the Number of the skillfullest Mariners that the World affords, which are my Native Countrymen of England.



CHAP. I.

Of a Sea-Journal.

BUT to proceed in the Practice of keeping a *Sea-Journal*, there are five necessary Things to be known by our young Navigator, *viz.* 1. That he rightly understands the Compass, with the Variation thereof; and that he must carefully observe the Course steer'd; in order to which, you are often to look to your Compass, and to the Wake of your Ship (if she be upon a Wind) to set it by your Compass, that you may give due allowance for her Lee-ward Way.

2. The Log-line and Half-minute Glass; that the Knots on the Log-line be a due Length, and your Glass just half a Minute.

Now as the half Minute Glass is $\frac{1}{2}$ part of an Hour, so the Log-line Divisions or Knots ought to be the $\frac{1}{12}$ part of a Sea Mile. A Statute Mile contains 5280 English Feet; and 5280 divided by 120 Quotes 44 Feet; but we usually allow but 42 Feet, or 7 Fathom between Knot and Knot on the Log-line, altho' several Authors of Navigation have contended for 50 Feet Distance between the Knots, depending upon such Land Experiments as have been made, that 66, or 70 Miles make one Degree of a great Circle upon the Superficies of the Earth or Sea; but I shall rather adhere to the good old Way of 42 Feet, for these Reasons, *viz.* 1. To give allowance for the Way that the Log makes after the Ship; for altho' there is 12, 15, or 18 Fathom of stray Line, (so much) allow'd as may be supposed to veer the Log moderately well out of the Ship's Wake; yet it cannot

not be supposed but that still the Log must have some Way after the Ship, if but by the Weight of the Line; which altho' but light, yet the Water being but a soft fluid Substance, the Log must needs have some Motion after the Ship, and especially sailing before the Wind; or large and in a fresh Gale, the Wind and Sea will have so much Effect upon the Log, and so much upon the superficial Part of the Water, as to shove it along after the Ship.

2. If there be an Error in the shortness of the Knobs, it is on the safer Side; for altho' the exact Truth is best, if it could be attain'd; yet if an Error must be, 'tis better that the Reckoning be a-head of the Ship, than that the Ship should be a-head of the Reckoning; and better to look out for Land before we come at it, than to be a-shoar before we expect it.

3. Most Mariners, both in the Royal Navy, and Merchant Ships, use this Division of the Log, and by their constant Practice and Experience, find the Success to answer their Expectations in any Voyage, much nearer than a much larger Division would do.

Of the Half-minute Glass.

That the half Minute Glass be of a due Length; or otherwise it must needs make the Ship to run more or less than indeed she does; therefore We shall shew a Way to measure a half Minute, or any small Portion of Time, by the Vibrations of a Pendulum, which may be demonstrated to be Equitemporal; This Experiment is mentioned by Mr. Henry Philips, in his *Advancements of the Art of Navigation*; and since quoted by most Authors of Navigation; and Experience confirms this Truth, That if there be a Pendulum whose Length (from the Center) is 38 Inches and half, it vibrates Seconds; or Sixty times in a Minute; therefore for the trial of your half Minute Glasses do thus;

Take a Bullet, and make fast a Thread or Silk, of the just length of $38\frac{1}{2}$ Inches; let there be a Noose on the end of the Thread, and let the very End of the Noose be just $38\frac{1}{2}$ Inches from the Center of the Bullet (as aforesaid); then hang it up by the Noose upon a small Pin where it may hang at Liberty, and swing freely, and so give it Way, and each Swing shall be a true Second of Time; that is, each Time that it passes by the Perpendicular let fall from the Pin on which it hangs, shall be half a Second; and every time of its return to

the Place where it first began its Motion is a true Second; and a Glass that runs, till the said Bullet hath made 30 returns, shall be a true half minute Glass.

But if the Ship hath any considerable Motion, make the String 7 Inches shorter, and there make a Knot to hold it by between your Finger and Thumb; then by the motion of the Hand cause the Bullet to ascend to an Angle of about 60° every Swing from the foresaid Perpendicular; then each Swing shall be equal to those above-mentioned. But those that have a Log-Line truly divided, and the Experience of a Glass in long Voyages of so true a Length, that their Dead-reckoning, (when carefully kept) hath agreed with their Observations, their making of Land, &c. hath fallen out according to Expectation, by their Account by dead-reckoning; such a Glass, or another of the same Length, ought to be prefer'd before any other, as a true half Minute Glass.

3. In finding the Lat. by Observation, you are, the first Opportunity, from some known Head-Land, to observe, and if you find (after you have computed how far the said Head-Land, &c. is to the Northward or Southward of you, and knowing its Latitude by good Tables) any apparent Fault in your Quadrant, to allow for it, *i. e.* So much in your future Observations, as you find by this Trial your Instrument is Northerly, or Southerly: For altho' a Quadrant or Fore-staff may be made by a good Workman, yet you shall rarely find where there are many Quadrants, or many Observers aboard of one and the same Ship, and observing at one and the same Time, that all their Observations shall be exactly the same, but differ sometimes 6. 8. 10. 20. or 30 Minutes, more or less; which must be imputed to some Defects, in those Instruments, or to the Difference in the observing, some Men observing too open, and others very close; which latter Sort I judge, do make the most accurate Observation; by reason they can easier, and oftner perceive the Sun's Motion when he is near the Meridian, than the former.

4. In sailing along Shoar it's convenient and safe, for avoiding the Dangers of the Shoar (especially on an unknown Coast; that is, where you are not well acquainted with the Shoals, &c.) that you steer $\frac{1}{2}$ a Point, or a Point, more to the Sea-ward in the Night time; also it's necessary, when you come near a Port, that you have a
right

right Understanding of the Quality of the Tides, which way the Floods and Ebbs set, and what Moon makes full Sea upon the Coast, that so it may be known how long to ride at Anchor, or lie by to wait the Tide, if you know you are too soon; or what Sail to make to save your Tide, if you fear being too late; and that by knowing the setting of the Flood or Ebb, you may know what Tack will be best to get on board, to take all the Advantages to haul your self close upon a Wind, (if it shrinks) and to judge well of your Course.

5. These few Things being premised, and that our young Navigator be perfect in the Solution of the Questions, in plain sailing Traverse, Mercator's Sailing, and to allow for known Currents, or Tides, to find the Variation of the Compass, to take and work a celestial Observation, &c. all which we have fully treated of in the foregoing Pages: Let us now suppose he is on board, as Master, Mate, Midshipman, &c. taking his Charge, (or otherwise for his Improvement or Satisfaction,) for any Voyage: He is first to see he has good Meridian (or common) Compasses, and (in far Southern Voyages) an Azimuth-Compass together with Logs and Log-Lines, (a Reel) and Glasses, for a Watch (or 4 Hours) $\frac{1}{2}$ Hour and $\frac{1}{4}$ Minute, with hand and Deep-Sea, Leads; and Lines in readiness; also Journal, and Log-Books. After the Navy, or Merchant-Ships Form (ruled and titled, in the Manner we shall shew a little farther on), with a good Quadrant, (Fore-staff and Nocturnal) for celestial Observation, plain and Gunter's-Scale, Pair of Compasses, Sea-Charts, &c. for Operation; these Things, I say, being in Readiness, he must also provide a Log-Board ruled, and mark'd, as you see in the Figure here-under.

The Form of the Log-Board.

H.	K.	F.	Course.	Winds.	Remarks.
1	—	—		N N W.	8 March the
2	—	—	Fresh	Gales and	5th. 1732.
3	—	—	fair	Weather	Yesterday at
4	—	—			6 in the E-
5	—	—	Reef'd	Top-Sails	vening, we
6	—	—	Lizard		took our
7	4		Point bore		Departure
8	5	N	N W dist.	5l. N b W.	from the
9	3	2	W S W		Lizard
10	3	1			bound for
11	3	5	moderate	and fair.	M. in Com-
12	4	4			pany of
1	3	6			three more
2	4	2		N W b N	Merchant-
3	4	6	Squalls of	Wind	Ships; at 8.
4	4	3	with	Rain.	A. M. stow-
5	4	1			ed our An-
6	3	5		N N W.	chors, and
7	4	3			hoisted in
8	3	4			our Long-
9	3	5			Boat.
10	4	2	S W b W		
11	5	3			
12	5	2	Moderate	and fair.	

The Log-Board you see is divided into six Columns, marked or noted at the Head of each Column, with Letters, thus;

H	} which stand- eth for	{	Hours, of the Day.	} run that Day.
K			Knots,	
F			Fathoms,	
C			Courses, steer'd that Day.	
W			Winds, which have blown that Day.	

Day ; the last Column is Remarks or Occurrences happening that Day, as parting with the Land, meeting or parting, with Ships Currents, setting of the Sea, handing of Sails, &c. as will plainly appear by the said Log-Board, being filled up with the first Day's Occurrences from the Land departed from ; which, before you lose sight of, you are to set with the Compass, (allowing the Variation) and compute its Distance from you ; then having settled your Watches, and order'd the Men (or Man) a Trick at the Helm for two Hours, as is usual ; let 'em observe carefully what Course he Steers by the Compass ; or if they be order'd to steer upon any given Course, let them take care to mind it, and at the End of two Hours, or rather, and much better every Hour. (for the oftner the better) which is the Custom in the Royal Navy, and *East-Indian-Men* ; let the Mate heave the Log, calling aft, a Couple of Hands (Men) to attend him, one to hold the Log-Reel, the other with the half Minute-Glass in his Hand : Let the Mate over-haul off the Line, (having first cast over board from the Taffrel, or Lee-Quarter of the Ship, the Log with three or four Fakes of Line into the Sea) till the red Rag come to his Hand, at that Instant the Mate says, turn ; the Man with the Glass immediately upon that Word, as the red Rag goes away, is to turn the Glass, replying, done ; and watching diligently ; when then the half Minute Glass is just out, the Man that holds the Glass, cries, stop ; whereupon the Mate stops, and hauls in the Line, observing exactly how many Knots and Fathoms are gone out, and sets it down on the Log-board, against the Hour at which the Log was heav'd, and thus proceed every Hour, all the 24 Hours, and then the Log-board will be full, next Day at Noon.

Then having provided a Log-Book, ruled every Page like the Log-board, with the Day of the Week and Month at top, take off the Log into your Book, and rub out the Chalks upon the Log-Board, after you have so done (at Noon ;) so is the Board ready for the next Day.

Note, that Mariners do keep their Reckonings by the beginning and ending of the Day, Astronomical, from Noon to Noon ; that is, any 24 Hours Log, from Noon to Noon, is dated by the Day upon which it ends, and not upon the Day upon which it begins ; thus if we set Sail *March* the 4th, that 24 Hours Log must be called *March* the 5th.

2. That some in their Log-Books, or Journals, do represent the Week-Days by the Characters of the 7 Planets, viz.

☉	Sun	} For {	Sunday
☾	Moon		Monday
♂	Mars		Tuesday
☿	Mercury		Wednesday
♃	Jupiter		Thursday
♀	Venus		Friday
♄	Saturn		Saturday



CHAP. II.

Practical Navigation.

PROCEED we now to work a Day's Log. And first, when the Ship hath had a fair Wind; that is, before it, quattering, or large; we must make allowance always for the Variation of the Compass, Growth of Sea, and known Currents, lying by, making and shortning Sail; let the Example be taken from the foregoing Log-Board, or Log-Book, where the Ship departs from the *Lizard-Point*, in the Lat. of $49^{\circ} : 56'$ N. and Long. $5^{\circ} : 23'$ W. bound, for M. in the Lat of — and Long. of — Course — Dist. — Merid. Dist. or Depar. — found by Case 1. of Mercator's Sailing.

Explication or Operation.

1. At 6 last Night the *Lizard* did bear from the Ship, N. N. W, but allowing 1 Point West Variation, (in the Chops of our *British* Channel) to the left hand, the Bearings corrected will be N. W. *b* N. consequently the the Ships Course from the *Lizard* must be on the opposite Point of the Compass, which is S. E. *b* S, and the Dist. per. Estimation is 5 Leagues, or 15 Miles; which is the first Course and Dist. (in this our first Day's Work.)

2. Observe to allow the Variation, if Westerly, to the left Hand of your Courses steer'd, by the Compass, but East Variation to the Right.

To

To make this very plain to our young Navigator, (as also to allow for the Lee-Way, when the Ship is upon the Wind,) I have here subjoin'd a Compass-Card, in which he is to lay the Point of the Compass steered directly before him, and count to the right Hand or left so many Points, as is to be allow'd for the said Variation, (or Lee-Way) and he will easily perceive the Course corrected.

3. The first Course the Ship steer'd was W. S. W.; but allowing one Point West Variation to the left Hand thereof, the Course corrected, or made good, is S. W. $\frac{1}{2}$ W. and the Dist. by Log. 79 Miles during the Time the Ship lay on that Course, which was from 6 in the Evening till 10 a Clock next Morning.

4. The second Course steer'd is S. W. $\frac{1}{2}$ W.; but allowing, (as before) 1 Point West Variation, the Course made good is S. W. and the Dist. run by the Log from 10 to 12 a Clock at Noon is 15 Knots, or Miles, allowing 7 Fathom to each Knot, and every Knot counted as 1 Mile, when the Log is hove every Hour, (but if it's hove but once in two Hours, you must double the said Dist. run by the Log.) and thus proceed, if there were more Courses on the Log-Board.

This done, collect your several Courses corrected, and Distance sailed, into a Traverse-Table, and work the said Traverse, as you were taught in Traverse-Sailing. See the Operation.

C	D.	P.	N	S.	E.	W.	Lat. of the Lizard is
S. E. $\frac{1}{2}$ S.	115	3		12.5	8.3	65.7	19° : 56' N°. α . Lat.
S. W. $\frac{1}{2}$ W.	79	5		43.9		10.6	1° : 7' Sly.
S. W.	15	4		10.6			48:40 N°. Lat per 12d
α	Lat.	or So.	67.0			76.3	49° : 56' Mer. Par.
						8.3	48° : 49' 1468—3364
		Dep. or West.				68.0	Mer. α . Lat. 103m.
		ing.					

As α . Lat. Depart. $\therefore$ R. .. Tang. Course. —
67m. — 68m. — T 45° — T 45° : 34.

As S. C. Depart. $\therefore$ R. .. Dist. run, —
S .. 45° 34' — 68m — S. 90 — 95 Miles,

As α . Lat. 67m. Depart. 68m. $\therefore$ Merid. α . Lat. 103m.
 α . Long. 104m. or 1° : 44' W.

Then *Lizard* Long. ——— 5° : 23' W.
∞. Long. ——— 1 : 44' W. add.

Long. in *per* Account. ——— 7 : 07 W.

Lastly, Because the direct Course from the *Lizard* is S : 45° : 34' Wt. therefore the *Lizard* must bear (on the opposite Point) N° 45° : 34' Et. Dist. 95 Miles, or 32 Leagues. Thus is this first Day's Work finished, and you may place it down in the vacant Space to the right Hand of the Day's Log, in the Log-Book, thus ;

(♂ or) Tuesday March 5, 1732.

This 24 Hours the first Part, fresh Gales and fair Weather, the middle sometimes moderate and fair, and other times squalls of Wind with Rain, but the latter Part, moderate and fair, at 6 P. M. the *Lizard*-Point bore off us N. N. W, dist. about 5 Leagues, from which I take my Dep. in Company with three Sail of Merchant-Men. My Course *per*. Account is, S° : 45° : 34' W.

Distance ——— 95m.

Southing ——— 67.

Westing ——— 68.

Lat. in *per*. Dd. ——— 48° : 49' N.

Merid. Dist. ——— 68m. W.

∞. Long. ——— 105 W.

Long. in ——— 7° : 07 W.

The *Lizard* bears from the Ship N. 35° : 34' E. Dist. 32 Leagues.

Note, That the three Proportions, in this Day's Work, may be wrought by *Gunter's* Scale, by Case 6th, plain Sail. Meth. 1. and Case 3. Mercat. Sailing, or Case 2. middle Lat. Sailing. Or the *∞*. Long. may be found by the Traverse-Table and middle Lat. as directed in Case 4th, middle Lat. Sail. and this, or any other Day's Work, may be wrought by the Pen or Inspection, in all the various Methods proposed in plain Sailing ; to which I refer you.

The Log-Book, <i>Ex. 2.</i>				
D. (or Wednesday.)				
March 6, 1732.				
H.	K.	F.	C.	W.
Occurrences.				
1	5	2	W	N. E N E
2	4	5		
3	3	1		
4	3	4		
5	3	4		
6	4	3		
7	4	4		
8	4	2		
9	5	3		
10	5	4		
11	5	1		
12	6	3		
1	6	2		
2	6	2		
3	6	1		
4	6	3		
5	6	1		
6	6	6		
7	6	6		
8	6	4		
9	5	—		
10	5	—		
11	5	—		
12	6	—		
128m				
This 24 hours fresh Gales and fair Weather, and a great Sea from the Eastern Board.				
Magnet. Amp. E. $18^{\circ} : 05' S.$ True Amp. E. $29 : 12 S.$				
Variation W. $11 : 07$				
Sun's Zenith Dist. $50^{\circ} : 17' S.$ Sun's Declinat. $1 : 30 S.$				
Lat. by Ob. No. $48 : 47$				
Course W. Dist, $141 m.$ Westing $141 m.$ Lat. per Acc. $48^{\circ} : 49' N.$ Merid. Dist. $209 m. W.$ x. Long. $214 m. W.$ Long. in $10^{\circ} : 41' W.$ Lizard No. $72 : 12 E.$ Dist. 74 Leagues.				

In this second Day's Motion the Ship sails but on one Course, viz. W. b. N, with Allowance for 1 Point West Variation, the Course made good is West. And with respect to the great Eastern Sea following the Ship (going quartering) I allow one Knot (or Mile) more in 10, for the Dist. run by the Log, that is, the Run by the Log being 128 Knots, or Miles, I allow 13 Miles more, which makes it 141m. Miles.

Expli-

Explication.

The Course being West (or East) Dist. 141m. the Lat. in *per*. Account is the same as yesterday, viz. $48^{\circ} : 49'$, and the $\times$. of Long. is found by Case 2d of Parallel Sailing, or by the 2d. Case mid. Lat. Sailing, calling the Comp. mid. Lat. there, the Comp. Lat. here, because in this Case the Dist. and Depr. are the same.

As S. C. Lat. $\times$. Dist. (or Depr.) : : $\times$. Long.
 — S $41^{\circ} : 11'$ — 141m. — S. 90° — 214m
 or in Deg. and Min. $3^{\circ} : 34'$. W. which added to the Long. the Ship was in yesterday, viz. $07^{\circ} : 07'$ W, gives $10^{\circ} : 41'$. W the Long. the Ship is in; also the Westing or Depr. 141m. added to yesterday's Merd. Dist. 68m. W. makes 209m. W. the Merd. Dist. or whole Westing or Depr. from the Lizard.

And Subtr. the Lat. in — — — — — $48^{\circ} : 49'$ N
 From the Lizard's Lat. — — — — — $49^{\circ} : 56'$ N
 the Remainder is the $\times$. Lat. or Southing from the Lizard 67m.

Then to find the Bearings and Dist. from the Lizard, we have given the $\times$. Lat. 67m, and the Merd. Dist. or 209m. to find the Course and Dist. by Case 6th of Plain-Sailing.

As $\times$. Lat. Depr. $\times$. Tang. Course.
 67m. — 209 — T. 45° — T. $72^{\circ} : 12'$

As S. C. .. Depr. : : $\times$. Dist.
 S. $72^{\circ} : 12'$ — 209m — S. 90° — 221m. or near 72 Leagues. So that the Lizard bears

N. $72^{\circ} : 12'$ E. Dist. 72 Leagues, and your Day's Work is finished; therefore enter all the foregoing Operations in your Log-Book; as you see here is done above,

Example 3. Variation $\frac{1}{2}$ pt. West.					
24 (or Thursday) March 7, 1782.					
H.	K.	F.	C.	W.	Occurrences.
1	5	2	S W $\frac{1}{2}$ S.	N E.	This 24 Hours close Weather, with some Rain and fresh Gales of Wind and variable, sometime calm, a great Sea from the N. E. Board at 6 P.M. made a trial of the Current, and found it to set E. N. E. 1° and half Knot an Hour.
2	6	1			
3	7	—			
4	2	—			
5	1	—			
6	—	—	calm	Rain	
7	—	—			
8	4	5	S S W.	N $\frac{1}{2}$ E.	
9	6	—		N E $\frac{1}{2}$ N.	
10	5	2	S W.		
11	9	3			
12	5	4		N N E.	
1	5	6		Rain	Course $S^{\circ} 26^{\circ} 30' W.$ Dist. — — — 102m. Sourthing 90 Miles. Westing 45m. N. Lat. p. Judge. $47^{\circ} 17'$ Merid. Dist. 254m. W. x. Long. 68m. W. Long. in $11^{\circ} 49' W.$ Lizard No. $38^{\circ} 50' E.$ Dist. 99 Leagues
2	6	—	S W $\frac{1}{2}$ S.		
3	6	—		N E.	
4	6	—			
5	6	3	S. W. $\frac{1}{2}$ W.		
6	7	—			
7	7	2			
8	6	—			
9	7	—			
10	8	—	S W $\frac{1}{2}$ W.		
11	8	3		N E $\frac{1}{2}$ E.	
12	9	—	185m. per	Log.	

The several Courses corrected, by allowing $\frac{1}{2}$ Point West Variation to the left Hand of each Course, will be as in the Traverse-Table following, viz.

C.	D.	P.	N.	S.	E.	W.	Also the Cur-
SSW $\frac{1}{4}$ W.	21	$2\frac{1}{4}$		19.0		9.0	rent, setting, E
SW $\frac{1}{4}$ W.	11	$1\frac{1}{4}$		10.7		02.0	N E. corrected
SW $\frac{1}{2}$ S $\frac{1}{4}$ W.	26	$3\frac{1}{4}$		20.9		13.1	is ENE $\frac{1}{4}$ N.
SSW $\frac{1}{4}$ W.	18	$2\frac{1}{4}$		16.3		07.7	or NE $\frac{1}{4}$ E $\frac{1}{4}$
SW $\frac{1}{4}$ W.	33	$4\frac{1}{4}$		22.2		24.4	E at the rate
SW $\frac{1}{2}$ S.	25	$3\frac{1}{4}$		18.5		16.8	of 1 Mile and
ENE $\frac{1}{4}$ N.	36	$5\frac{1}{4}$	18.5		30.9		half in an hour
			S.	108.5	76.2 W.		is 36 Miles in
			N.	18.5	E. 30.9 sub		24 hours ;
X Lat. — 90.0 S. Depr. 45.3 W.							Which I place
of the Courses.							in the Traverse
							Table, & work
							it with the rest

Then ;

As π . Lat. Depr. :: R. T. Course $26^{\circ} : 30'$

As S. C. .. R. :: Depr. .. Dist. 101m.

Lat. yesterday ————— $48^{\circ} : 49'$ Mer. P. π . Lat. Sub. — 1 : 30 3328

Lat. to Day per. Account. 47 : 19 — 3228

Merid. & Lat. ————— 134

Merid. Dist. yesterday 209m. W.

Westing or Depr. made to Day 45. Add.

Merid. Dist. to Day 254 W.

As π . Lat. Depr. :: Mer. π . Lat. .. π . Long.————— 68m. or ————— $1^{\circ} : 08'$ W.Long. yesterday was ————— $10 : 41$ W. Add.Long. in to Day ————— $11 : 49$ W.From Lat. Lizard ————— $49^{\circ} : 56'$ N.Sub. Lat. by Account ————— $47 : 19$ N.Remains π . Lat. 2 : 37 N.
60

Or in Miles.

157

As

As x. Lat. ... Dep. (or Merid. Dist.) : : Tang.
 45° ... Tang. bearing off the Lizard N. 58° : 58° E.

As S. C. ... Mer. Dist. ... R. ... Dist. from the Lizard 298m. or 99 Leagues. All which enter in your Log-Book as before.

Example 4. Variation 4 of a Point West.

2 (or Friday) March 3d, 1732.					Occurrences
H.	K.	F.	C.	W.	
1	4	2	SW by W.	N. E.	This 24 hours mod.
2	4	1			Gales and fair weather
3	4	3			at 4 P. M. spoke
4	5	1			with a Bristol Galley
5	3	1			that came from Leg-
6	5	2			horn, and bound for
7	4	5			London.
8	4	6			Had an Observation
9	5	5	S. W.	E. N. E.	and found a help to
10	3	4			the Southward 25m.
11	3	3			which I impute to
12	4	1			the South-western Sea
1	4	—		N. E. by N. W.	Zen. Dist. 46° : 25' S.
2	4	2			Declin. 0 : 23 S.
3	4	4		N. E.	Lat. per Obs. 45 : 42 N.
4	5	—			
5	—	—	By up N.	N. N. W.	
6	4	3		of N. W.	Course S. 44 : 05 W.
7	5	—	S. W.		Dist. 100m.
8	4	2	made		Southing 72m.
9	4	3	Sail.		V. Vesting 70m.
10	4	4			Lat. per Dd. 56° : 07' N.
11	4	5			M. dist. Correc. 359m.
12	5	—			Lon. Correc. 14 : 18 W.
Lizard bears North 51° : 21' East, Dist. 133 Leagues.					

1. In this Day's Motion, the Courses made good, with allowing $\frac{1}{2}$ per West Variation: To the Left-hand of each are S. W. $\frac{1}{2}$ W. 36m. .. S. W. by S. $\frac{1}{4}$ W. 37m; and lying by from 4 to 6 in the Evening, I allow 1 Mile for Drift to the N. W. And third Course steer'd Being the same as the second, viz. S. W. 28, you need only add both the Distances sailed together, which makes 65m. on the same Course, as above.

2. These three Courses and Distances reduced to one, by working a Traverse (Table) gives the Ship's Course this 24 Hours, to be S. $44^{\circ} : 05'$ W. Dist. 100m. Southings, 72m. Westing, 69m, 8 (or 70 very near) M. P.

Lat. Yesterday $47^{\circ} : 19'$ ——— 3232

Lat. sub. $1 : 12$

Lat. per. Dd. $46 : 07$ ——— 3126

Merid. x. Lat. = 106m.

To Merid. Dist. Yesterday 254m. W.

Add Westing made to Day 70m.

Sum is Merid. Dist. to Day 324 W.

As x. Lat. .. Dep. :: Mer. x. Lat. .. w. Long.

102 Miles, or $1^{\circ} : 41'$ W.

Long. in Yesterday W. ——— 11 : 49 Add

Long. in to Day ——— } 13 : 31

per. Account

But seeing that I am but in the Lat. of $46^{\circ} : 07'$ by my Reckoning, and in $45^{\circ} : 42'$ by Observation (which I must refer or trust to more than the dead reckoning.) So that the Ship (sailing to the Southward in North Lat.) hath out-run the Reckoning 25 Miles Southerly, which I judge is an Error in my Steerage or Course, in regard of the Southwest Sea, or that I have allow'd too little Variation of the Compass (for want of an Opportunity to observe it.) Therefore, to find the Course, Merid. Dist. and x. Long. Corrected;

Lat. Lizard $59^{\circ} : 50'$ ——— $46^{\circ} : 07'$ is

= 229m. the x. Lat. or Total Southings from the Lizard; and the total Westing, or Merid. Dist. is 324m. by dead Reckoning. Then,

As

As $\times$ Lat. .. Dep. :: $\times$.. T. Course,
 — 229m — 324m. — T 45° — T. $54^\circ : 45'$.

As S. C. .. $\times$:: Dep. .. Dist.
 — S. $54^\circ : 10'$ S. $10'$ — 324m — 399m. by dead
 Reckoning; which with the $\times$ Lat. by Observation
 from the Lizard, viz.

$49^\circ : 56'$ — $45^\circ : 42'$ = 250m. find the Course,
 Westing and $\times$ Long. Corrected by Case 3, Mercat. Sailing.
 Thus ;

	Merid. Parts.
Lat. $49^\circ : 56'$ — — — —	3468
Lat. $45^\circ : 42'$ — — — —	3095

Merid. $\times$ Lat. — — — — 373
 As Dist. .. $\times$ Lat. :: $\times$.. S. C. Course.
 — 399m. — 133m. — S. 90° — S. $38^\circ : 40'$
 Whole Comp. is $51^\circ : 20'$ So that the Lizard bears N.
 $51^\circ : 20'$ East. Dist. 399m. 133 Leagues.

As $\times$.. S. C. :: Dist. .. Merid. Dist.
 — S. 90° S. $51^\circ : 20'$ 399m — 312m. Wt. Correct.

As $\times$ Lat. .. Dep. :: Mer. $\times$ Lat. .. $\times$ Long.
 — 250m. — 312m. — 373m. — 465m.

Of, — — — —
 To which add the — — — — $7^\circ : 45'$ West.
 Long. of the Lizard, — — — — $5^\circ : 23'$ West.

Long. Corrected, — — — — $13^\circ : 08'$ West.
 which set down in your Log-Book accordingly.

2. And for a general Rule to correct the Reckoning on
 an Oblique Course, observe,

If your { more } than the Dep. the { Log. or Dist.
 $\times$ Lat. { Fault is most } Steerage, or
 be { less } likely to be in { Course.

2. But in a more Westerly (Easterly) Course, suppose a Ship sails from A, till his Course and Dist. by dead Reckoning is represented by the Line A I, and the Lat. come to by the Parallel G I, but By Observation he is in the Parallel of Lat. H L K : Now, if we suppose the Course was rightly judg'd of, and the Fault to be in the Dist. we must continue the Line A I, till it cut the Parallel H K, and allow him to be the whole Distance, I K, mistaken in his Account; which seems again absurd; and therefore let us impute the Mistake to the Course, and then with one Foot of the Compasses in A, with the Extent A I, describe the Arch I L, and draw the Distance A L, equal to A I; and suppose that when he thought he had sail'd along the Line A I, he had indeed sail'd along the Line A L, the Angle I A L being a much more tolerable Fault in the Course, than the Distance I K could be supposed in the Dist.

Hence, and from the aforesaid General Rule, when the Error is suppos'd to be in the Dist. by the Log (as most Generally is, by different Persons heaving of it, and other Reasons) this Proportion arises for correcting your Reckoning by an Observation. *viz.*

As the total Northing, or Southing, (or dead Reckoning $\times$ Lat.) is to total Easting or Westing, (or dead Reckoning Merid. Dist.) so is the Error in Northing or Southing, called the Correction in Lat. or the Difference between the Lat. by Reckoning and Observation, to the Error or Correction in Easting, or Westing, or Merid. Dist. For,

As A B dead Reckoning $\times$ Lat.

Is to B E dead Reckoning Dep.

So is B D = E g, Correction in Lat.

To g F, the Correction in Dep.

2. Having got the meridional $\times$ Lat. between the observ'd and dead Reckoning Lat.



Together with the Correction in Lat. and in Dep. And suppose in the annexed Scheme. Let A B be the Correction in Lat. and B D the Correction in Dep. A C the Merid. $\times$ Lat. between the observ'd and dead Reckoning Lat. C E the Correction in Long.

Then the Proportion is, As A B, the Correction in Lat. is to B D, the Correction in Dep. So is A C, the Merid. $\times$ Lat. to C E, the Correction in Long.

Q

Which

Which two Proportions are evident from the 4th Prop. of Lib. 6. Euclid, the Triangles being similar.

Note, the dead Reckoning, $\propto$ Lat. and Dep. must be collected from the beginning of the Voyage, if it be the first Error (or Correction) otherwise from the last Error; or from the last Observation, to the Day of the present Error.

If in case your Course be far Easterly, or Westerly, and you find an Error between the dead Reckoning Lat. and observed Lat. it is best to trust to the observ'd Lat. and not meddle at all with the Departure, or $\propto$ Long. because the Error is so small; as in the foregoing Scheme, the true Departure H L differs so little from the dead Reckoning Dep. G I, that 'tis not worth while to correct it.

Now, if you should judge that there is an Error as much in the Course as in the Dist. then you must part the Difference; as for Example;

If you think you have sailed by the Rhumb-line A F, S. S. W. and to be arrived at E, in the Parallel of Lat. B E. and your Observation sheweth, that you are in the Parallel of Lat. D F. Draw the Line E *g* parallel to a Meridian, and then take the Point *g* for the Place of your Ship; that is, take the observed Lat. A D and Dep. by Reckoning, B E = E *g*, to find the corrected Course, Dist. and Dep.

Again; if you have an Observation every Day or two, and find some Difference between your Observation and dead Reckoning Lat. 'tis best to judge well of the Course made good, and with that and the observed $\propto$ Lat. work your Day's work by Case 2, Mercator's Sailing.

To correct the dead Reckoning upon a North or South Course, when the dead Lat. differs from that observ'd.

You must correct the Ship's Place in the same Meridian, and in the observed Parallel.

Example.

Suppose a Ship sail 80 Leagues South from A, till by my Reckoning, she is in the Point B in Lat. 46° . but by Observation she is in the Point D, in Lat. $45^{\circ} : 46'$, which I must trust to rather than by the reckoning Lat. The same is to be understood if you had sailed North.

To correct your Reckoning, upon an East or West Course, if there be an Error you cannot discover by your Observation, if any Current sets with or against the

the Ship ; therefore 'tis best to alter your Course a little, that by the Diff. of Lat. you may discover the Error.

When you have sail'd several Leagues or Miles East, or West, and find by your Observation, that you have not been under that Parallel where your Reckoning places you, then your Reckoning must be corrected by your observed Difference of Lat. and Distance ; as for Example,

Suppose a Ship sails W. 150 Miles, from A, in the Lat. of 50, to M, and by Observation the Ship is found in the Lat. of 49 : 00, then with one Foot of your Compasses in A, with the Dist. A M, describe the Arch M L, so shall L be the Place of the Ship in the parallel Lat. of 49° : And here we have also the Dist. and observed $\times$ Lat. to find the corrected Course, Depart. &c.

Lastly, and Generally, the Error lieth in the Log, or Distance ; and this is that which most usually makes the Difference between the observ'd Lat. and the Lat. by Reckoning : And herein are two Cases.

Case 1. In North Lat. sailing toward the North, and in South Lat. sailing toward the South.

If the observ'd Lat. be the greater, then hath the Ship out-run the Reckoning ; but if it be the lesser, the Reckoning hath out-run the Ship.

Case 2. In North Lat. sailing towards the South, and in South Lat. sailing towards the North.

If the observed Lat. be the greater, then hath the Reckoning out-run the Ship ; but if it be lesser, the Ship hath out-run the Reckoning.

So that when the Ship hath out-run the Reckoning, then is the Reckoning too little, and it must be augmented ;

But when the Reckoning hath out-run the Ship, then is the Reckoning too great, and must be lessened ; that is, the Correction in Departure must be added to, or subtracted from the meridional Distance, according to the Cases above.

And the Correction in Long. (according to the new way of counting it) if the Long. in, and its Correction, be both East or both West, add ; but one East, and the other West, subtract ; and the Longitude is corrected.

§. 3. *To work a Day's Log, or to keep account of a Ship's Way upon a Wind.*

A Ship (in the Sea-Phrase) is said to sail upon a Wind, when her Tacks are a-board, and her Yards sharp Braced, and the Bowlines haled forward, and is commonly sup-

posed to lie up within 6 Points of the Wind (tho' Yachts, Sloops, and Hoys, or Smacks &c. will lie much nearer to the Wind) a Ship's Lee-Way is counted according to the Sail she carries, *viz.*

All Sails set, i. Point.

Topails, all Reefs taken in, and a great Sea, 1 Point.

A Topfail taken in, 2.

Both Topails taken in and a Sea, 3.

Try under Main-sail and Mizzen, 4.

Try under Main-sail only, 5.

Under a Mizzen only, 6.

Lying or Trying a Hull, all Sails furled, 7.

These are the usual Allowances for Lee-Way, and by which we shall Work the following Examples: Nevertheless in Practice Lee-Way must be allowed according to Judgment, for some Ships make more Lee-Way than others, with the same Sail set, &c.

And respect also must be had to the smoothness of the Water, or to the Sea's running high; and then the Allowance for Lee-way being rectified and adjusted by setting the Ship's Wake by the Compass, or Quadrant of a Circle, which is usually (or ought to be) placed on each Rail of the Ship's Quarter for that purpose.

To allow for the Lee-way, Star-board Tacks a-board, allow the Lee-way to the Left-hand of your Course by the Compass, but Larboard Tacks a-board towards the Right.

I therefore with West Variation and Starboard Tacks a-board, the Sum of the Variation and Lee-way, is the Allowance to the Left-hand, to make your Course good from the Point the Ship lies up to by the Stem; but with West Variation, and Larboard Tacks a-board: If the Variation is greater than the Lee-way, the Diff. must be counted to the Left-hand of your Course; if less, to the Right; if equal, you make your Course good according to the Compass.

Example.

1. If the Ship be upon a Wind, with her Star-board Tacks a-board, and Stem W. S. W. the Wind at N. W. 1 Point Wt. Variation and Topails set. 1 Point Lee-way is allowed in this Case; her Course made good is S. W. but with her Star-board Tacks a-board, she would make her Course good at N. N. E. because her Lee-way and the Variation are equal: For the Variation being one

one Point W. the Ship lying up N. N. E. her Course allowing the Variation, is N. by E. but allowing 1 Point Lee-way from the Wind, brings it again to N. N. E. All which plainly appears, if you lay the Chart of the Compass (foregoing) before you.

2. If the Wind blow hard and cause one Topfail to be handed or taken in, the Variation still 1 Point West, Starboard Tacks a-board, the Wind at N. W. Ship Capes, or lies up W. S. W. then allowing 2 Points Lee-way, her Course is S. W. by S. but with her Starboard Tacks N. E. by N.

3. If it blow so hard that both Topfails are taken in, and the Sea run high, and you allow 3 Points Lee-way; then in the Case above, her Course with her Starboard Tacks a-board, is S. S. W. and with her Larboard Tacks N. E.

4. If the Fore-sail be furled, and she try under a Main-sail and Mizzen, you allow 4 Points Lee-way; then in the Case above, her Course will be with her.

Starboard } Tacks { S. by W.
Larboard } { N. E. by E.

5. If she try under a Main-sail only, and you allow 5 Points Lee-way, then in the Case above, her Course will be with her

Starboard } Tacks { South.
Larboard } { E. N. N.

6. But if she try under a Mizzen only, and you allow 6 Points Lee-way; then in the Case above her Course

Starboard } Tacks is { S. by E.
Larboard } { E. by N.

7. If she be a-Hull, with all her Sails furld, and you allow 7 Points Lee-way, then in the Case above her Course on the

{ Starboard } Tack is { S. S. E.
{ Larboard } { East.

That is, with allowing 1 Point West Variation in all these seven Examples.

8. If the Wind hath blown hard at N. W. and made a high Sea, the Ship stemming as before, W. S. W. but the Wind shifting to the South while the Sea continues to run high, it taking the Ship on the Lee-bow, abates the Lee-way. These Directions, with a little Practice, and consideration of the Ship's Trim, Sail aboard, stress of Wind, and growth of the Sea, will for strengthen our young Navigator's Judgment (for whose sake I have taken this Pains) that he'll seldom fail of making a true Allowance.

We shall proceed now to some particular Examples in working a Day's Log, the Ship being upon a Wind.

Th (or Saturday) March 4th. 1732.					
H.	K.	F.	C.	W.	Occurrences.
1	4	3	W. S. W.	N. W.	Variat. Point W.
2	5	2	Mod.	and Fair.	
3	6	1		W N W.	This 24 Hours the
4	6	2			most part fresh Gales
5	6	---	S S W.	West.	and Rain, with vari-
6	6	1			able Winds.
7	5	4	Fresh	Gales.	
8	5	2	S.	W S W.	Course S. 12°:15' W.
9	5	1		Rain.	Dist. 108 m.
10	5	---			Southing 105 m.
11	5	---			Westing 23 m.
12	4	3	S S E.	S W.	Lat. pr. Dd. 44:01 N.
1	4	2		Fair.	Mer. Dist. 32 m. W.
2	4	---			Long. 32 m. W.
3	4	2	Tackr.	S by W.	Long. in 83°:40' W.
4	5	---	W: by S.	Rain.	The Lizard bears
5	5	1			N° 43°:18' E.
6	5	3			Dist. 162 Leagues.
7	5	2	S S W.	S E.	
8	5	1			
9	5	2			
10	5	---		E S E.	
11	5	3			
12	5	1	Reeft.	Tonfais.	

In this Day's Sailing, the Ship hath had her Starboard Tacks a-board, from 12 at Noon, till 2 in the Morning; the Topfails being set, I allow 1 Point Lee-way, and $\frac{1}{2}$ Point West Variation, is 1 Point $\frac{1}{2}$ I must allow to the Left-hand of the Log Courses during that Time: So that the Courses corrected according to the former Directions, are (with the Dist. sailed on each, viz. S. W. $\frac{1}{4}$ VV. 10m. S. W. $\frac{1}{4}$ W. 12m. S. $\frac{1}{4}$ W. 18m. S. by E. $\frac{1}{4}$ E. 15m. S. E. by S. $\frac{1}{4}$ E. 18. Then at 2 in the Morning the Ship tack'd to the Westward; therefore having her Larboard Tacks on Board till Noon, the variation $\frac{1}{2}$ Point West abates the Lee-way to $\frac{1}{4}$ Point, which I allow to the Right-hand of the Log. Courses; which makes them (when corrected) W. by S. $\frac{1}{4}$ W. 18m. S. S. W. $\frac{1}{4}$ W. 21m. S. $\frac{1}{4}$ W. 16m. These Courses and Dist. being collected in Order, and the Traverse work'd as before taught, will give the Southing 105m. Westing 23m. Course S. 12° : 15' W. Dist. 108m.

Lat. Yesterday per. Observat.	45 : 46	3095
∞ Lat. S ^o sub.	1 : 45	1
Lat. per Acct. to Day	44 : 01	2947
Meridional ∞ Lat.		148
Meridional Dist. Yesterday		312 VV.
Westing made to Day		23
Meridional Dist. to Day		335 VV.
As ∞ Lat. .. Dep. ∴ Mer. ∞ Lat. to the ∞ Long.		0 ^o : 32' VV.
Long. in Yesterday Add		13 : 08 VV.

Long in to Day 13 : 40 W.

From Lat. Lizard 49° : 56' sub. Lat. in 44° : 01, remains the ∞ of Lat. 5° : 55' or 355 miles

As ∞ Lat. Merid. Dist. ∴ R. T. C. 43° : 18'

As S. C. ∴ Mer. Dist. ∴ Dist. 487 Miles.

Or 162 Leagues So that the Lizard bears from the Ship N^o 43° : 18' E. Dist. 162 Lgs. which Day's work enter in your Log-Book accordingly.

© (or Sunday) March 5th, 1732.					
H.	K.	F.	C.	W.	Occurrences.
1	5	1	S. by W.	S. E. b. E.	Variat. 3 P. W.
2	3	--	Handed	F. Topf.	This 24 Hours
3	3	1			Hard Gales of
4	3				wind and thick ha-
5	2	4			zy weather, and a
6	2	5			great Sea from the
7	2	3			S. E. Board.
8	2	2	S. S. W.	S. E.	Cour. S. 51° 20' W.
9	2	3			Dist. 57 m.
10	3	--	Handed	M. Topf.	Southing 36 m.
11	2	1			Westing 45 m.
12	2	2			Lar. per Account
1	2	3			43° : 25' N.
2	2	1	S W by S.	S. E. b. S.	Mer. Dist. 380 m.
3	2	2			West.
4	2	1			x. Long. 62 m. W.
5	2	1			Long. in 14° : 42'
6	2	1			West.
7	2	3			D°. N. 44° : 08' E.
8	2	3	S. W.	S. S. E.	Dist. 181 Leagues.
9	2	4			
10	3	--	Reeft	Courfes.	
11	3	1			
12	3	1			

In this Day's Motion, the Ship hath had on Board her Larboard Tacks. The first Hour her Topsails being set, but close reefed and a great Sea, I allow $1\frac{1}{2}$ Point Lee-way, and Variation as (above) half Point West, which abates the Lee-way to 1 Point: So that the first Course corrected is S. S. W. Dist. 3m. but seeing at 2 a Clock the Fore-Topsail was taken in, I allow on the above-said (Log) Course 2 Points Lee-way, which makes the Course good with the Variation, S. S. W. half W. and Dist. by the Log till 8 a Clock, is 17m.

The next Course is S. S. W. which with the same allowance corrected, is S. W. by S. half W. and the run from 8 to 10 a-Clock is about 5 Miles; then at 10 a-Clock the Main-Topfail was taken in, and the Ship under her 3 Courses, *viz.* Fore-Sail, Main-Sail, and Mizzen; therefore I allow 3 Points Lee-way on the said S. S. W. Course, which with the abatement of half Point W. Variation makes the Course corrected S. W. half W. and the Dist. run from 10 till 2 in the Morning is 11 Miles.

The next Course is S. W. by S. which by the above said allowance makes it good at S. W. by S. half W. and the run from 2 a-Clock till 8 is 13 miles.

The next Course by the Log is S. W. which with the above said allowance corrected is W. S. W. half W. and the run from 8 in the Morning till Noon is 14 miles.

So that the several Courses (with the Distances) corrected or made good are, *viz.*

S. S. W. 17 Miles; S. W. by S. half W. 5 Miles; S. W. half W. 11 Miles; S. W. by W. half W. 13 Miles; W. S. W. half W. 14.

Which Traverse being wrought, you'll find the Southing 36 Miles; Westing 45 Miles; Course S. 51 : 20' W. Dist. 57 Miles.

			M. P.
Lat. Yesterday	44° : 01'		1947
* Lat. Sub.	0 : 36		
Lat. to Day per. Account	43 : 25		2897
Meridional * Lat.			50
Merid. Dist. Yesterday		535m. W.	
Westing this 24 Hours		45 add	
Merid. Dist. to Day		38° W.	
As * Lat. .. Dep. :: Merid. *. of			
Lat. .. * Long. 62m. or		1° : 02' W.	
Long. in Yesterday, Add		13 : 40 W	

Longit. in to Day 14 : 42 W.

Lat. Lizard 49° : 56' — Lat. in 43° : 25'
is equal to * Lat. 6° : 31'. or 394 miles.

As Δ . Lat. $\dots$ Dep. $\dots$ Tang. Course.
 $\dots$ 39m $\dots$ 380m $\dots$ T. 45° $\dots$ 44° $\dots$ $08'$.
 As S. C. $\dots$ B. $\dots$ Dep. $\dots$ Dist.
 $\dots$ S. 44° $\dots$ $8'$ S. 90° 380m 543m. or 81 Legs.

So that the *Lizard* bears N. 44° $\dots$ $08'$ East.
 Dist. 181 Leagues.
 All which Day's work place in your Log-Book, as before.

D (or Monday) March 6th, 1732.					
H.	K.	F.	C.	W.	Occurrences.
1	3	6	up Fore	fail	Variation $\frac{1}{2}$ Point W.
2			S. by W.	S. E. by E.	
3			Try un	der M. S.	Hard Storms of
4			and	Mizen	wind and thick ha-
5			S. by E.	E. by S.	zy weather, with
6			reeft &	Ballast.	some Rain, and a ve-
7			the Mi	zen.	ry great and hollow
8			Try un	der a	grown Sea, all this
9				Mainfail	24 hours.
10			S. S. E.	E.	
11				Rain.	Course S. 24° $34'$ W.
12			up Main	fail.	Dist. 38 Miles.
1			Try un	der a	Southing 35 Miles.
2			Mizen		Westing 16 Miles.
3					Lat. p. Ac. 42° $50'$ N.
4					Mer. Dist. 396m. W.
5			E. S. E.	N. E.	x. Long. 22 m. W.
6			(plit our	Mizen to	Long. in 15° $04'$ W.
7			Pieces.		D. N. 42° $50'$ E.
8			Try a	Hull.	Dist. 194 Leagues.
9					
10					
11				Rain.	
12					

In this Day's Motion, the first Hour the Ship was under her Courses, I allow 3 Points Lee-way; but the Variation half Point West, being counter (to or) contrary to the Lee-way, it makes it but 2 Points $\frac{1}{2}$ there.

therefore the Course corrected is S. W. by S. half W. Dist. 4 Miles; then at 8 haul'd up the Fore-sail, and laid a Try under the Main-sail and Mizzen, till 8 a-Clock, for which I allow 1 Mile an Hour Drift, which is 7 Miles; and allowing 4 Points Lee-way, and the Variation as before, for the 2 Courses S. by W. and S. by E. it makes them S. W. half W. in 4 Hours 4 Miles; and S. S. W. half W. in 3 Hours more 3 Miles. Then at 8 a-Clock haul'd up the Mizzen, and lay a Try under the Main-sail only till 12, for which I allow 1 $\frac{1}{2}$ Mile Drift an Hour, makes 6 Miles Drift; and the Courses S. by E. and S. S. E. corrected, with Variation and Lee-way allowed. (*viz.* half Pt. less 5 Pts. = 4 half Pts.) is S. W. by S. half W. from 8 to 9 a-Clock 1 Mile; and S. S. W. half W. in 3 Hours, 3 Miles; then at 12 haul'd up the Main-sail, and set the Mizzen only till 8 in the Morning, for which I allow 2 Miles an Hour Drift, and 6 Points Lee-way, with the Variation, as above, makes the Courses laid up S. S. E. to be S. W. by S. half W. from 12 to 5 a-Clock 10 miles; and the E. S. E. Course to be S. half E. in 3 Hours Drift more, 6 miles. — Then at 8 in the Morning the storm and Tempest being so violent as to split the Mizzen (Sail) to Pieces, we lay a Try a-Hull, (or under the bare Poles as the Sea-Phrase is) till 12 at Noon; for which I allow 2 Miles and half Drift, an Hour, and the Lee-way 7 Points, and the Variation as above makes the E. S. E. Course corrected, with 6 Points, and a half, S. half W. and the Drift on it in 4 Hours, 10 Miles.

So that the several Courses corrected by Judgment, with their Distances, are, *viz.*

S. W. by S. half W. 4m. S. W. half W. 4m.

S. S. W. half W. 3m. — S. W. by S. half W. 1m.

S. S. W. half W. 3m. S. W. by S. half W. 10m.

S. half E. 6m. — S. half W. 10m. —

These 8 Courses may be reduced to 5, by putting the several Distances on the same Courses together; for the first, fourth, and 6th Courses are the same, and the Distances added together, 4, 1. and 10 make S. W. by S. half W. 15 miles.

The third and 5th Courses are the same; and the Distances put together are S. S. W. 6 $\frac{1}{2}$ miles.

The second, seventh and eighth Courses are,
 S. W. half W. 4m. S. half E. 6m. S. half W. 70m. 110m.
 Which Traverse wrought makes the Southing 35m.
 Westing 16m. Course S. 24° : 34' W. Dist. 38 Miles.

Lat. Yesterday, 43° : 25' ——— 2897

" Lat. subt. 00 : 35 ——— 2897

Lat. per Account 42 : 50 ——— 2849

Merid. " Lat. ——— 48

Merid. Dist. Yesterday, ——— 380m. W.

Westing to Day, Add ——— 16

Merid. Dist. to day ——— 396 W.

As x Lat. : Dep. : Merid. x. of 2

Lat. " x. Long. 5 0° : 23' W.

Long. in Yesterday add ——— 14 : 42 W.

Long. in to day, ——— 35 : 04 W.

Lat. Lizard 49° : 56' ——— 79 : 06

Or 426 miles the whole Southing, or " Lat. from the Lizard.

As " Lat. " Dep. : " L. Course S. 42° : 50' W.

As S. C. " R. : " Mer. Dist. " Dist. 194 Lgs.

Therefore the Lizard bears from the Ship North 42° : 50' E. Distance 194 Leagues. Then this 24 Hours Work enter also in your Log-Book, and you've done.

March

♂ March 12. 1732. Log hove every 2 Hours.					
H.	K.	F.	C.	W.	Occurrences.
	set	f. sail	S. S. W.	N. E.	Variat. half Point W.
2	5	3	Fresh	Gales.	This 24 hours the
4	5	5		N. E. b. N.	first and middle
6	6	3			Part fresh Gales and
8	6	5	set fore.	Top-sail.	close weather. The
10	7	3			latter moder. and
12	7	4		N. E.	fair at half past
2	7	5	set	Main-sail.	12 at Noon, bent
4	8	1	S. b. W.	N. E. b. E.	a new Mizzen, and
6	8	3	set M.	Top-sail.	bore away.
8	9	---	Mod.	and fair.	⊙ Z. Di. 39°:56' S.
10	9	2	S. b. W. $\frac{1}{2}$	West.	⊙ Dec. 0:28 N.
12	9	4	set Miz.	Top-sail.	Lp. Ob. 40:24 N.

Course S. 12°: 50' W. Dist. 181 Miles.

Southing 176 m. Westing 40 Miles.

Lat. per Dd. 39°: 54' N.

Merid. Dist. correct. 446 Miles W.

Long. correct. 16°: 30' VWest.

D°. N°. 38° E. Dist. 242 Leagues.

In this Day's Sail the Ship hath gone with a quarter (or fair) Wind, and a great Sea from the N. E. board following the Ship, and therefore we shall allow 1 Mile in 10 more of the Dist. for the Sea heaving home the Log; and because the Log was heav'd but once in two Hours, double the Dist. run on each Course:

Then to correct the Courses, with allowance of $\frac{1}{2}$ Point West Variation (as above) only toward the Left. The first Course corrected is S. by W. half W. and Dist. 43 Knots; doubled, taking in the double of 28 Fathom, viz. 56, or 8 Knots, makes 94 Miles, to which I add 9 Miles more for heaving back the Log, makes 103 Miles, the Dist. run on this first Course till 8 in the Morning. The same being allow'd in the other two Courses, makes them S. half W. 50m and S. b. W. 42m. This Traverse solv'd gives the Southing 16m. Westing 44 Miles, Course S. 12°: 50' W. Dist. 181 Miles.

Lat.

Lat. yesterday ——— $42^{\circ} : 50'$ ——— Mer. Parts
 Southing Subtr. ——— $3 : 16 = 196m.$ 2849

Lat. per Dead. ——— $39 : 34$ ———

Merid. $\times$ Lat. ——— ——— ——— 134m.

Merid. Dist. yesterday ——— ——— ——— 396m. *W.*
 Westing to day add. ——— ——— ——— 44

Merid. Dist. per Account ——— ——— ——— 440 *W.*

As $\times$ Lat. Depr. $\therefore$ Merid. $\times$ Lat. $\therefore$ $\times$ Long.

Long. in yesterday add. ——— ——— ——— $00^{\circ} : 53'$ *W.*

Long. per Account ——— ——— ——— $15 : 04$ *W.*

Long. per Account ——— ——— ——— $15 : 57$ *W.*

But seeing, by a good Observation, to day I find the Ship in Lat. $40^{\circ} : 24'$ N. whereas by my Account of dead Reckoning, I am in the Lat. of $39^{\circ} : 54'$. So that my Reckoning hath out-run, or is a-Head of the Ship 30 miles; so that I may suppose there hath been some Current, or that I have not exactly computed the Course and Dist. by the Log, but rather shall conclude, that for two or three days last past, we have had a great Sea, from the Eastern, and S. E. board, which hath set the Ship more to the N. *W.* than per Judgment; therefore, imputing the Error to the Dist. because my Southing is more than the VVesting, since last day of Correction, March 8. where my Meridian Dist. was 312m. *W.* and to day is 436, the difference is 124m, the dead Reckoning Depr. Then,

Lat. March 8. was per Ob. ——— $45^{\circ} : 46'$ ———

Lat. per. Account to Day. ——— $39 : 54$ ———

————— $5 : 52$ ———

————— 60 ———

Dd. reckoning $\times$ Lat. ——— 352 miles. ———

————— M. P. ———

Lat. } per. { Ob. } to Day. { $40^{\circ} : 24'$ — 2654

Dd. } { $39 : 54$ — 2615

—————

Error in Lat. 30m. and in M. $\times$ Lat. — 39

————— Merid. ———

Merid. $\times$ Lat. between the observ'd and reckoning Lat. is 39m.

Then the Propotion is,

As dead Reckoning $\times$ Lat. 352m.

Is to dead Reckoning Depr. 124

So is Correction in Lat. 30.

To Correction in Depr. 10.

And as Correction in Lat. 30m.

Is to correction in Depr. 10m.

So is Merd. $\times$ Lat. 39m.

To Correction in Long. 13m.

Merid. Dist. per Account 436 W.

Correction in Depr. Add. 10 W.

Merid. Dist. corrected 446 W.

Long. in per Account. 15° : 57' W.

Correction in Long. add. 0 : 13 W.

Long. corrected 16 : 10 W.

Lat. of the Lizard 49° : 56' N.

Lat. per Observat. to day 40 : 24 N.

$\times$ Lat. S^oly. from the Lizard. 9 : 32 or, 572 miles.

As $\times$ Lat. .. Depr. : : R .. T C. —
572m — 446 — T. 45° — S. — 38° : W.

As S. C. Depr. : : R .. Dist. — S. — 38° — 446m.
— S. 90. — 726 or 242 Leagues. So that the Lizard bears

N. 38° E. distant from the Ship 242 Leagues which with the corrected Merid. Dist. and Long. &c. I place in my Log-Book ; as you see.

Thus I think I have sufficiently shewn our young Mariner how to work a Day's Log. when the Ship is by, or Large, (that is, with a foul or fair Wind) and in all weathers ; and the Method of making Allowances for Variation of the Compass, Currents, Lee-way, Drift, Growth of Sea, and other known Impediments ; and also given him demonstrative Rules and practical Examples, for rational Corrections, when he finds an Error in his Reckoning, &c. with other experienced Rules and

and Methods, which hitherto hath been wanting in Authors, and the Generality of Teachers of Navigation. I shall draw to a Conclusion of this Part; supposing, if the Learner understands what is here laid down, 'twill be as useful to him as if I had inserted (as I thought to have done) an actual Run, from the *Lizard* to *Lisbon*, *Madera*, &c. which would both have augmented the Book and its Price; the *Sheers* having already exceeded my designed Brevity, by endeavouring to make every thing, (necessary in the Theory and Practice of this noble and useful Art) as plain, perspicuous, and intelligible as possible, to the most indifferent or meanest Capacity.

I would further here inform our young Artist, that it's both usual, and also useful, when you sail from *England* far to the South-westward, as for Instance; to *Barbadoes*, in the *West-Indies* to steer, something to the Southward of your direct Course; because if, you will sooner have the Advantage of a Trade, (or fair) Wind, and *aly*, bring your Ship in a Parallel, or East and West-Course to the Island bound to; and so by keeping your Ship, as nearly in that Parallel, as you can by your Observation, (or Dead-Reckoning) that you may more certainly hit, or fall in with the Island.

And in coming from the S. Westward towards *England*: As for Instance, from the abovesaid Island, you sail, to the Northward of your direct Course, that you may sooner get into a variable Wind's way, and so make the best Advantage to gain your Port in the shortest Time; always diligently and strictly looking out for the Land, before you approach too near it by your reckoning.

Now if at any Day at Noon (when your Day's Run is work'd) you would know how (*Madera*, or) such a head Land you draw near or are bound to, bears from the Ship, you have always given the Lat. and Long. your Ship is in, and the Lat. and Long. of the said Place (found in the Tables of Lat. and Long. or Chart) to find the Course and Dist. by the first Case of *Mercator's*, or mid. Lat. Sailing.

Or if you would find the Point in the *Mercator's* Chart, that represents the Ship's Place; or to find the Bearings and Dist. from the Ship to such or such Head-Land or Place, you may find the same, by the Directions of the use of *Mercator's* Chart, before *Mercator's* Sailing, Page 76, and 77. foregoing.

5. The preceding Log-Book may indifferently serve both for Log-Book and Journal, together, according to the *India*, or Merchant-Ships Form; — but we shall shew how a Journal is kept, according to the Form of the Royal Navy. — In which Method the foresaid Log-Book is to represent the Waste-Book in Accounts; but the Journal is to represent the Ledger, or Fair-Book, rul'd and titled as here under the left Side of each Folio, for the Day of the Month, Week, Winds, Course, Dist. Lat. Long. and Bearings, and Dist. of head-Lands, &c. The right Side of each Folio is to contain the Winds and Weather, and all remarkable Occurrences, that happen in the whole Voyage. In the first Page of your Journal, write the Title thereof thus;

A Journal of a Voyage (by God's Assistance) in his Majesty's Ship, C. Captain A. B. Commander.

From the *Lizard* in $\left\{ \begin{array}{l} \text{Lat. } 49^{\circ} : 56' \text{ N.} \\ \text{Long. } 5 : 23 \text{ W.} \end{array} \right\}$ to the
Island *Madera* in $\left\{ \begin{array}{l} \text{Lat. } 32^{\circ} : 17' \text{ N.} \\ \text{Long. } 17 : 22 \text{ W.} \end{array} \right\}$

The Course from the *Lizard* is $S. 27^{\circ} : 09' \text{ W.}$
Dist. in that Rhomb. 327 Leagues,

Merd. Dist. or Westing $9^{\circ} : 03'$
u. Long. ————— $12^{\circ} : 03' \text{ W.}$

Kept by H. K. —————
Commencing March 5. 1732.

But if in a Merchant-Ship, leave out the two Words his Majesty's; and write in their room, In the good Ship, C. &c.

Then every Day at Noon transfer or post the Day's Work into the Journal, in manner following, which is a Journal of eight Days, as taken from the foregoing Log-Book.



R
R

W.
W.

W. D.	M. D.	Winds per Compass	Course Corre- cted.	Dis- in M.	Lat. Corre- cted.	Long. Corre- cted.	Merid. Dist. and bearing and Dist. of Head - Lands at Noon.
1732.							
March.		N.N.W.					Merid. Dist. 68m.
		N b. w.					W. the Lizard,
							at Noon, bears
							N. 49°:14' E.
							Dist. 30 Lgs.
♂	5	NW b. N	S.:49:	90	48:49	7:07 W.	
			49:W.		N.		
		N N W					
							Merid. Dist. 204m.
							W. D°.
							N° 71°:49' E.
							Dist. 72 Lgs.
♀	6	E.N.E.	West.	136	48:47	10:33 W.	
					N.		
							Merid. Dist.
		N. E.					257m. VV.
		to					D°.
		N.b.E.	S.31:12				N° 58°:45' E.
4	7	back to	W.	102	47:20	11°:52'	Dist. 100 Lgs.
		N.E.b.E.			N.	VV.	

Remark-

*Remarkable Occurrences, on board his Majesty's
Ship C. from the Lizard towards Madera.*

March 5. 1732.

THIS 24 Hours the first and middle Part, fresh Gales, close Weather, and sometimes Rain, the latter part moderate and fair. Yesterday at 6, P. M. the Lizard-Point bore N. N. W. Dist. about 5 Leagues, from which I take my Departure bound to *Madera*, in company with three more Merchant Ships at 8 A. M. stowed our Anchors and hoisted in our Long-Boat. Course, Dist. Lat. Long. &c. as per Columns.

March 6.

This 24 Hours fresh Gales of Wind and fair Weather, and a great Sea from the Eastern Board. This A. M. observ'd by an Amplitude at Sun-rising and found the Variation, about 11° West.

March 7.

This 24 Hours close Weather with some Rain, fresh Gales of Wind and Variable, sometimes calm. A great Sea from the N. E. Board made Trial of the Current, and found it to set E. N. E. $\frac{1}{2}$ Mile an Hour.

W. M.	Winds	Cours.	Dis.	Lat.	Long.	Merid. Dist. and
D. D.	per	Corre-	in	Corre-	Corre-	Beating, and Dis.
1732.	Com-	cted.	M.	cted.	cted.	of Head - Lands
	pafs.					last seen.
28	N.E.					Meridian Dist.
	E.N.E.	0				312 m. W.
	N.E. 6 N	40:15 W				D ^o .
	N.E.		104	Obs. 0	13:08 N	N ^o . 51 ^o : 21' E.
						Dist. 133 Lgs
29	N.W.	S. 12:15			3:40	Merid. Dist. 235 W
	E. S. E.	W.	108	44:01	W.	D ^o . N. 48 ^o : 18' E.
						Dist. 162 Lgs.
30	S. E. E.					Merid. Dist. 280 m.
	to					W.
	S. S. E.	S. 51:20	57	43:25	14:42 W	D ^o .
	W.	W.				N. 44 ^o : 08' E.
						Dist. 181 Lgs.
31	S. E. E.					Merid. Dist. 396 m.
	to					W.
	E.					D ^o . bears
	and	S. 24:34	38	42:50	15:4 W.	N. 42 ^o : 40' E.
	N. E.	N.				Dist. 194 Lgs.
32	N. E.	S. 12:50	18	Obs. 16:10		Merid. Dist. 446 m
	N. E. 6 E.	W.		40:24	W.	D ^o . N. 38 ^o E.
						Dist. 248 Lgs.

Remarable Occurrences on Board the C. March 8.

This 24 Hours moderate Gales and fair Weather at 4 P. M. spoke with a Bristol-Galley, that came from Leghorn, bound for London. By a good Observation to Day, I find a Help to the Southward 21 Miles, with respect to the South-Western Sea; so that my Merid. Dist. and Long. corrected, is, as per Columns.

March 9.

This 24 Hours the most Part fresh Gales, and Rain, with variable Winds.

March 10.

This 24 Hours hard Gales of Wind, and thick hazy Weather, and a great Sea from the S. E. Board at 2 P. M. handed Fore-Topfail, at 10 D°. Main-Topfail, and at 10 A. M. reefed Courses.

March 11.

This 24 Hours hard Storms of Wind, and thick hazy Weather, with a very hollow grown Sea from the S. E. Board, at 1 P. M. up Forefail; try under Mainfail and Mizzen, at 6 D°. reefed and ballast the Mizzen, try under a Mainfail; at 2 at Night, up Mainfail, try under a Mizzen; at 6 A. M. split the Mizzen to pieces, try a Hull.

March 12.

This 24 Hours fresh Gales and fair Weather; at $\frac{1}{2}$ Pt. 12 at Noon bent a Mizzen, bore away and made Sail, steering our proper Course.

For the Sake of the Curious, I have invented an Instrument hereunder, which I call the Nautical Medal: Or, Navigator's Pocket-Piece. By which you may (without any Burthen to the Memory) work a Day's Work by the Pen, and Square Root, as we have shew'd in Method 3 of Plain-Sailing. This Pocket-Piece is easily understood; for on one Side you have the Natural Sines, or given Numbers to every Point, and half

Point of the Comp. standing to the Right-hand of the said Points or Quarters ; together with brief Rules for working *Pl. Sailing* and *Mid. Lat.* And on the other Side you have, (for more exactness) the given Numbers of Sines, to every Degree of the Quadrant. These circular Pieces may be cut out, and pasted on each side a round, smooth, and thin Piece of Wood, and then are fit for (and will take up but little more Room than a Crown Piece in) the Pocket. The Use whereof altho' we have already shewn in *Meth. 3. Plain-Sailing* ; yet for the Learner's Benefit, shall work by it the first Day's Log foregoing.

Example.

The Courses there (corrected) with their Distances, are, *viz.*

S. E. by S. 15m. S. W. by W. 79m. S. W. 15m.

That is $\left\{ \begin{array}{l} 3 \\ 5 \\ 4 \end{array} \right\}$ Points whose Numbers on the Piece are, $\left\{ \begin{array}{l} 555. \\ 831. \\ 707. \end{array} \right.$

Then,

As R. .. Dist. :: S. C. 3 .. Dep.
m. m.
— 1000 — 15 — 555 — 8,325.

As R. .. Dist. :: S. C. C. 5 x Lat.
m. m.
— 1000 — 15 — 831 — 12,465.

As R. .. Dist. :: S. C. 5. .. Dep.]
m. m.
— 1000 — 79 — 831 — 65,649.

As R. .. Dist. :: S. C. C. 3. .. x Lat.
m. m.
— 1000 — 79 — 555 — 43,845.

As R. .. Dist. :: S. C. 4 .. Dep.
m. m.
— 1000 — 15 — 707 — 10,6.

And 10,6 is also the x Lat. because the Course is 4 Points. Now

Now the several $\times$ Latitudes, or Southings 12,5m ; 43,9 ; and 10,6 ; added together, makes total $\times$ Lat. or Southing, to be 67 Miles. And the Sum of the Westings, or Departures, 65,7m. and 10,6m. is 76,3m ; from which subtract the Easting, or Departure, 8,315, remains 68 Miles, the Westing or Departure made ; both of which exactly agree with what before was found by the Traverse-Table.

$$\begin{aligned} \times \text{ Lat. } 67 \times 67 &= 4489 \text{ Sqr. } \times \text{ Lat.} \\ \text{Depart. } 68 \times 68 &= 4624 \text{ Sqr. Depart.} \end{aligned}$$

$$\text{— From Z Sqr. } \sqrt{9113} (= 95 \text{ Dist.})$$

The Dists. 95 more $\frac{1}{2}$ the greater Side the Depart. 34 is = 129 the Z.

Less Side. Giv. Nr.

As Z 129 .. 67 $\times$ Lat. $\therefore$ 86 .. $44^{\circ} \frac{1}{2}$, the Angle opposite to the lesser Side ; which being the $\times$ Lat. 'tis the Comp. of the Course : Therefore from 90° : 00', take $44^{\circ} : 30'$, remains $45^{\circ} : 30'$, the Course South-westerly.

$$\text{Lat. } \left\{ \begin{array}{l} \text{Lizard} \\ \text{in} \end{array} \right\} \begin{array}{l} 49^{\circ} : 56' \\ 48 : 49 \end{array} \text{ — } 1^{\circ} : 07' = 48^{\circ} : 49'$$

$$\text{Z} = 98 \quad 45$$

$$\text{Z} = 49 : 22 \text{ Mid. Lat.}$$

$$\text{Subt. from } 90 : 00$$

$$\text{Remains } 40 : 38 \text{ S. C. Midd. Lat.}$$

but we shall take it for 41° . Whose Natural Sine (on that side of the Piece the whole Degrees are on) is 6560 ; which because the Natural Sine is four Figures, the Radius must be 1,0000. Therefore say,

$$\text{As S. C. Mid. Lat. } \dots \text{Dep. } \therefore R \dots \times \text{Long.}$$

$$\text{— N. S. } 6560 \text{ — } 68m \text{ — } 1,0000 \text{ — } 103,65m.$$

Or nearly 104m — or $1^{\circ} : 44'$ W. which added to $5 : 23'$ W. the Long. of the Lizard, makes $07^{\circ} : 07'$ West, the Long. the Ship is in.

So that the Course is $S^{\circ} . 45 : 30' \text{ W.}$

Dist. 95m. Southing 67m. Westing 68m.

Lat. in $48^{\circ} : 49'$ N. Merid. Dist. 68m. W.

$\times$ Long. 104m W. Long. in $07^{\circ} : 07'$ West.

And the Lizard bears $N^{\circ} . 45 : 30' \text{ East.}$

R

Dist

Dist. 95m. or 32 Leagues very near; agreeing with the Traverse-Tables, Logarithms, or Gunter's Scale, and almost as expeditiously performed, by those that can readily multiply and divide, and extract the Square Root, (which Extraction may be taught and learn'd in half an Hour, by any Person that understands Division): And as for the Proportions in working the Traverse of the Day's Work, the first Number in the Proportions you see (is Radius) 1,000 (or 1,0000); therefore you've nothing to do but multiply the second and third Numbers together, and cut off from the Product three Figures, or four, (as many as there are Cyphers in the first Number) and the Remainder to the Left-hand is the Miles of the Departure, or $\propto$ Lat. and those to the Right-hand so cut off are the Decimal Parts of a Mile.

— So in finding the $\propto$ Long. you need only annex four Cyphers to the Right-hand of the second Number, in the Proportion, and divide it by the first Number, the Quotient exhibits the Miles, and the Remainder the Decimal Parts of a Mile for the $\propto$ Long.

Secondly, We shall also work that useful Case in Navigation, where there is given the $\propto$. Long. and $\propto$. Lat. to find the Course, Dist. and Dep.

Example.

What's the Course, Dist. and Westing from the Lizard to Madera?

Example.

Lizard } in { $49^{\circ} : 56' N^{\circ}$ } Long { $5^{\circ} : 23' W$
Madera } L. { $42 : 17 N$ } { $17 : 22 W$

$\propto$ Lat. = $17 : 39$ or $1059m.$ $11 : 59$

Z $82 : 13$

60

: Z & Md. Lat. $41 : 06$ $\propto$ Long. 719 Miles,

90 : 00

S. C. Md. Lat. $48 : 54$

For which I shall

take 42° whose Natural Sine on the Piece is, 7547.

1. Then

Then, As *Cafe*, *gd. of Plain Sailing*,

As *Lat.* $\times$ *Long.* $\div$ *S. C. Mid. Lat.* $\div$ *Dep.*
 $\frac{10000}{719m} = \frac{7547}{542,6293,1101}$

Or near 543 Miles.

4. As the 6th *Cafe of Plain Sailing*,

$\times$ *Lat.* $1059 \times 1059 = 1121481$ *Sqr.* $\times$ *Lat.*

Dep. $543 \times 543 = 294829$ *Sqr.* *Dep.*

$\frac{2}{m.}$
Sqr. $\sqrt{1416310} (= 1190$ Or 397

Leagues.

Dist. $1190 \div \frac{1}{2} \times$ *Lat.* $529 = 1719$ the *Z.*

Z *Dep.* *G. N.*

As $1719 \div 543 :: 86 \div 27^\circ : 09', i. e.$ the

Course is *S. 27: 09. W.* *Dist.* 397 *Lgs.*

Dep. *Meridional Dist.* or *Westing*, 181 *Leagues*, exactly agreeing with the *Logarithmetick Solution* thereof, as you may prove.

Note, To bring out the odd Minutes of the Angle for the *Course* in the last *Proportion*, multiply the last *Remainder* after *Division* by 60 , (the Minutes of a Degree) and divide that *Product* by the same *Divisor*, the *Quote* gives the Minutes required.

Thus may the curious Learner work a *Day's Log*, or *Sea Journal* by any, or all the other *Methods* by the *Pen*, that we have shewn in *Plain-Sailing*, and made reference to in *Mercator's Sailing*, which I leave to the *Industry*, and *Improvement* of our young *Student*.

And thus having finished what I hope may (if duly studied in the *Theory*, and carefully applied in the *Practice*) bring the diligent Learner to be a compleat *Artist* in this famous *Art* of *Navigation*, which has for its *Hand-maids* or *Attendants*, no less than *Three* out of *Seven*; nay, I might have said, all the *Mathematical Liberal Sciences*; I shall here conclude, in allusion to a *Circle* and *Triangle*, the most excellent of all *Geometrical Figures*, and the *Principal Figures* also in *Navigation* and *Astronomy*; I say, in allusion to the *Circle*, the *Emblem* of *Eternity*, and the *Triangle* of the *Triune Deity*, the *Trinity* in *Unity* and *Unity* in *Trinity*,
 who

who created the Heavens, Earth, Sea, and all Things therein of Nothing, in Number, Weight, and Measure.

To whom be all the Glory, and Honour, and Adoration, *in Sacula Saculorum.* Amen.

The End of the PRACTICAL
NAVIGATION.



The Conclusion.

O Thou Urania, thou that now hast brought
 Our Ship to Harbour safe, and richly fraught;
 Tho' **ÆOLUS** his blustering Gales did send,
 And foaming Billows high the Skies did rend:
 The blustering Storms, and Thunder loud did roar,
 And Darkness grim oppress'd our Souls all o'er,
 So that we could not view the Stars, nor Sky,
 Nor Sun, nor Moon, nay, Earth could not espy:
 Yet by thy Art, such Safety we did find,
 Tho' roughly toss'd by raging Seas and Wind,
 As at the last a Harbour safe did gain.
 Rejecting Fears, we quite cast off our Pain.
 When Seas are calm, and Winds more serene be,
 Then we again will put our Ship to Sea,
 That when refresh'd, we farther may descry,
 And search into this **ART** and **MYSTERY**.



Nemo Sine Crimine Vivit.

MEnd (gentle Reader) what has 'scap'd amiss;
 And then it matters not whose Fault it is:
 The Printer sins, I sin much like the rest,
 And all Men sin since Adam first transgress'd.
 Yet here our Comfort is, tho' both offend,
 We to our Faults can quickly put **AN END**.
 Transgressor-like, I've to the Press been hurl'd,
 From thence sent forth to a Censorious World;
BOUND to my good Behaviour; and to pray
 For a kind Passage, that all Envy may
 Be quiet, and no crack-brain'd Scep'tick grudge;
 Let Art examine, then let Candor judge.
 Let what's well done (Reader) oblige your View,
 And let good Nature pardon Errors too;
 We err by Custom from old Adam's Act,
 Still Heirs unto that meritorious Fact:
 Then let each gen'rous Soul afford this kindness,
 Correct our Faults, for these admit no **FINIS**.

1. *Multiplication by Logarithms.*

Rule. **A**DD the Log. of the Numbers together, the Sum is the Log. of the Product.

Examp. Multiply 14 by 11.

Logarithm of 14 is 1.146128 } Add:
 Logarithm of 11 is 1.041393 }

Logarithm of 154 the Product is 2.187521

2. *Division by Logarithms.*

Rule. Subtract the Logar. of the Divisor from the Logar. of the Dividend, the Remainder is the Logar. of the Quotient.

Ex. Divide $\left\{ \begin{array}{l} \text{Log. of } 125. \text{ --- } 2.096910 \\ 125 \text{ by } 5. \text{ } \left\{ \begin{array}{l} \text{Log. of } 5. \text{ --- } 0.698970 \\ \text{Log. of the Quote, } 25 \text{ --- } 1.397940 \end{array} \right. \right. \end{array} \right. \text{ } \left. \begin{array}{l} \text{Subt.} \\ \text{---} \\ \text{---} \end{array} \right.$

3. *Rule of Three, or Proportion by Logarithms.*

Rule. Add the Logs. of the 2d. and 3d. Numbers together, and from that Sum subtract the Log. of the first Numb. the Remaind. is the Log. of the 4th. Nr. required.

Ex. If a Ship sails 79 Miles in 24 Hours, how long will she be sailing 129 Miles? *Anf.* 39h.

Log. $\left\{ \begin{array}{l} 79\text{m} \text{ --- } 1.897627 \\ 24\text{h} \text{ --- } 1.380211 \\ 129\text{m.} \text{ --- } 2.110589 \end{array} \right.$

3.490800

Log. 39h. 1.593173

N. B. This Rule of the Logs. holds good in all the Proportions made in Navigation, Astronomy, &c.

4. *Square Root extracted by Logarithms.*

Rule. $\frac{1}{2}$ the Log of the Square Number is the Log. of its Square Root.

Examp. What's the Square Root of 121 Miles?

Log of 121m 2.082787

Log. of 11. Square Root $\frac{1}{2}$ = 1.041392

5. *Cube Root extracted by Logarithms.*

Rule. $\frac{1}{3}$ of the Log. of the Cube Numb. given, is the Log. of the Cube Root requir'd.

Ex. What is the Cube Root of 125m?

Log. — 125m. 2.026910 } the Cube Root requir'd.

Log. — $5. \frac{1}{3}$ = 0.698979 }

Soli DEO Gloria.



A TABLE of the Dominical Letters, Cycle of the Sun, Prime, Epact, Moveable Feasts, and Eclipses for 16 Years.

Years.	Domin. Letter.	Sun's Cycle.	Prime.	Epact.	Shrove-Sunday.	Easter-Sunday.	Whit-Sunday.
1732	BA	5	4	14	Feb. 20	Apr. 9	May 28
1733	G	6	5	25	7	Mar. 28	13
1734	E	7	6	6	24	Apr. 14	June 2
1735	E	8	7	17	16	6	May 25
1736	DC	9	8	28	Mar. 7	25	June 13
1737	B	10	9	9	Feb. 20	10	May 29
1738	A	11	10	20	12	2	21
1739	G	12	11	1	Mar. 4	22	June 10
1740	FE	13	12	12	Feb. 16	6	May 25
1741	D	14	13	23	8	Mar. 29	17
1742	C	15	14	4	28	Apr. 18	June 6
1743	B	16	15	15	18	3	May 24
1744	AG	17	16	26	4	Mar. 25	13
1745	F	18	17	7	24	Apr. 14	June 4
1746	E	19	18	18	9	Mar. 30	May 18
1747	D	20	19	29	Mar. 1	Apr. 19	June 7

ECLIP.

ECLIPSES of the Sun and Moon for 16 Years.

Anno 1732.

1. ☉ Eclips. May 28. Invisible.
2. ☉ Eclips. June 11. Invisible.
3. ☉ Eclips. Novemb. 8. Invisible.
4. ☾ Eclips. Novemb. 20. Visible and Total.
5. ☉ Eclips. Decemb. 6. Invisible.

Anno 1736.

1. ☉ Eclips. Mar. 1. Invisible.
2. ☾ Eclips. Mar. 15. Visible and Total.
3. ☉ Eclips. Mar. 30. Invisible.
4. ☉ Eclips. Aug. 25. Invisible.
5. ☾ Eclips. Septemb. 8. Visible and Total.
6. ☉ Eclips. Sept. 23. Invisible.

Anno 1733.

1. ☉ Eclipsed May 2. Visible 10 Digits.
2. ☾ Eclipsed May 17. Visible and Total.
3. ☉ Eclipsed Octob. 26. Invisible.
4. ☾ Eclipsed Novemb. 10. Invisible.

Anno 1737.

1. ☉ Eclips. Febr. 28. Visible 11 Digits.
2. ☾ Eclips. March 5. Invisible.
3. ☉ Eclips. August 14. Invisible.
4. ☾ Eclips. Aug. 28. Visible 6 Digits.

Anno 1734.

1. ☉ Eclips. April 22.
2. ☉ Eclips. October 15. both Central, but Invisible.

Anno 1738.

1. ☉ Eclips. February 7. Invisible.
2. ☉ Eclips. August 4. Visible 4 Digits.

Anno 1735.

1. ☾ Eclips. Mar. 27. Invisible.
2. ☉ Eclips. Apr. 11. Invisible.
3. ☾ Eclips. Septemb. 20. Visible 7 Digits.

Anno 1739.

1. ☾ Eclips. Jan. 13. Visible 8 Digits.
2. ☉ Eclips. January 27. Invisible.
3. ☾ Eclips. July 9. Invisible.
4. ☉ Eclips. July 24. Visible 7 Digits.

Anno

Anno 1740.

1. ☾ Eclips. Jan. 2. Visible 20 Digits.
2. ☉ Eclips. Jan. 17. Invis.
3. ☉ Eclips. June 13. Invis.
4. ☾ Eclips. June 28. Invis.
5. ☉ Eclips. Decemb. 7. Invis.
6. ☾ Eclips. Decemb. 21. Visible 6 Digits.

Anno 1741.

1. ☉ Eclips. June 2. Invis.
2. ☉ Eclips. Novemb. 27. Invis.

Anno 1742.

1. ☾ Eclips. May 8. Invis.
2. ☉ Eclips. May 23. Invis.
3. ☾ Eclips. Novemb. 2. Invis.
4. ☉ Eclips. Novemb. 16. Invis.

Anno 1743.

1. ☉ Eclips. April 13. Invis.
2. ☾ Eclips. April 27. Invis.
3. ☉ Eclips. May 12. Invis.
4. ☉ Eclips. Octob. 6. Invis.
5. ☾ Eclips. Octob. 21. Visible 21 Digits.
6. ☉ Eclips. Novemb. 5. Invis.

Anno 1744.

1. ☉ Eclips. April 1. Invis.
2. ☾ Eclips. April 15. Visible 8 Digits.
3. ☉ Eclips. Septemb. 25. Invis.
4. ☾ Eclips. Octob. 10. Invis.

Anno 1745.

1. ☉ Eclips. March 22. Invis.
2. ☉ Eclips. Septemb. 14. Invis.

Anno 1746.

1. ☾ Eclips. Feb. 24. Invis.
2. ☉ Eclips. March 11. Invis.
3. ☾ Eclips. August 19. Visible 6 Digits.
4. ☉ Eclips. Septemb. 4.

Anno 1747.

1. ☉ Eclips. Jan. 29. Invis.
2. ☾ Eclips. Feb. 14. Visible 20 Digits.
3. ☉ Eclips. Feb. 28. Invis.
4. ☉ Eclips. July 26. Invis.
5. ☾ Eclips. August 9. Invis.
6. ☉ Eclips. August 24. Invis.

N^o. 3. A Table of the Moon's Shining, Distance from the Sun, and her Motion for every Day and Hour of her Age.

Age	Shines		Dist. a. Q.		Mot.			Age	Mot.		N ^o	Sign
	L.	M.	S.	D.	S.	D.	M.		D.	M.		
0	12	0	0	0	0	0	0	1	0	32	1	♈
1	12	48	0	12	0	13	11	2	1	36	2	♈
2	1	36	0	24	0	26	21	3	1	39	3	♈
3	2	24	1	6	1	9	32	4	2	12	4	♈
4	3	12	1	18	1	22	42	5	2	45	5	♈
5	4	0	2	0	2	5	53	6	3	18	6	♈
6	4	48	2	12	2	19	3	7	3	51	7	♈
7	5	36	2	24	3	2	14	8	4	24	8	♈
8	6	24	3	6	3	15	25	9	4	56	9	♈
9	7	12	3	18	3	28	35	10	5	29	10	♈
10	8	0	4	0	4	11	46	11	6	2	11	♈
11	8	48	4	12	4	24	56	12	6	35	12	♈
12	9	36	4	24	5	8	7	13	7	8	1	♈
13	10	24	5	6	5	21	18	14	7	41	2	♈
14	11	12	5	18	6	4	28	15	8	14	3	♈
15	16*	0	6	0	6	17	39	16	8	47	4	♈
16	12	48	6	12	7	0	49	17	9	20	5	♈
17	1	36	6	24	7	14	0	18	9	53	6	♈
18	2	24	7	6	7	27	11	19	10	26	7	♈
19	3	12	7	18	8	10	22	20	10	59	8	♈
20	4	0	8	0	8	23	32	21	11	32	9	♈
21	4	48	8	12	9	19	53	22	12	5	10	♈
22	5	36	8	24	9	3	3	23	12	38	11	♈
23	6	24	9	6	10	16	14	24	13	11	12	♈
24	7	12	9	18	10	29	25					
25	8	0	10	0	11	12	35					
26	8	48	10	12	11	29	46					
27	9	36	10	24	0	8	56					
28	10	24	11	6	0	22	27					
29	11	12	11	18								
30	12	0	12	0								

N^o. 3. TABLE showing the Moon's Changing for 8 Years.

Years.	Jan.	Febr.	Mar.	April.	May.	June.	July.	August.	Sept.	October.	November.	December.
	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.	D. H. D. H.
1732	16.1 a	14.1 a	15.8 m	13.5 a	13.2 m	11.0 n	10.12 a	9.2 a	8.5 m	7.10 a	6.5 a	5.1 m
1733	5.1 m	3.2 a	5.1 m	3.9 m	2.5 a	30.9 m	29.7 a	28.7 m	26.1 a	26.5 a	25. N	25.7 m
1734	23.12 a	22.2 a	23.12 a	22.10 m	21.5 a	20.1 m	19.8 m	17.4 a	16.4 m	15.6 a	14.1 m	14.6 m
1735	13.2 m	11.8 a	13.0 N	12.1 m	11.10 a	9.6 a	9.1 m	7.8 m	5.4 m	5.3 m	3.4 a	3.8 m
1736	2.1 m	None	1.4 a	29.10 a	29.9 m	27.5 a	27.1 m	25.9 m	23.5 a	23.3 m	21.3 a	21.5 m
1737	19.9 a	18.3 a	2.9 m	19.1 m	18.4 a	17.4 m	16.3 a	15.1 m	13.9 m	12.6 a	11.5 m	10.3 a
1738	9.6 m	7.6 a	9.10 m	8.2 m	7.5 a	6.8 m	5.11 a	4.0 N	2.11 a	2.10 m	30.7 m	29.5 a
1739	28.5 m	26. a	28.5 m	26.7 m	26.9 m	24.12 a	24.4 a	23.7 m	21.9 a	21.10 m	19.9 m	18.10 m

A TABLE of the Moon's Soutbing.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Afternoon.
Time	h. 17	h. 18	h. 19	h. 20	h. 21	h. 22	h. 23	h. 24	h. 25	h. 26	h. 27	h. 28	h. 29	h. 30	h. 31	Morning.
Sou.	10.48	1.36	2.24	3.12	4.0	4.48	5.36	6.24	7.12	8.0	8.48	9.36	10.24	11.12	12.0	

RULES for the Moon's Rising and Setting.

R U L E II

Increase { ☉ rising + } shining = } rising }
 { ☉ setting + } shining = } setting }

Decrease { ☉ rising - } shining = } rising }
 { ☉ setting - } shining = } setting }

R U L E 2.

☾ New } Rises and sets with the Sun.
 ☾ Full } Rises at Sun setting, and sets at Sun rising.

☾ Beginning to Increase, riseth a little after Sun rising, and sets a little after Sun setting.

☾ Beginning to Decrease, riseth a little after Sun setting, and setteth a little after Sun rising.

☾ In her first Quarter rises about Noon, and sets about Midnight.

Lastly, ☾ Riseth every day 48 Minutes latter as in her Southing. But this is according to her Mean Motion, without respect had to her Latitude, &c.

NOTE, When it's New Moon, the Sun and Moon are both in the same Sign and Degree of the Ecliptick. And then the Sun may be Eclipsed, by the Moon coming between the Sun and our Sight.

At Full Moon she is Opposite to the Sun: And then the Moon may be Eclipsed, by the Earth's Interposition between the Sun and Moon exactly Diametrical.

N^o. 4 *A Table of the Angles which every Point of the Compass maketh with the Meridian: Also the Time answering each Point.*

North.	South.	North.	South.	Point	D.M.	H.M.
Note, Each Point is $\frac{1}{2}$ of an hour, to be reckon'd North-easterly to the South, and South-westerly to the North Point. N. by E. S. by E. N. by W. S. by W. Divide 360° by 32. the Points, the Quote is $11^{\circ} \frac{1}{4}$, each Point of the Compass.						
				$\frac{1}{2}$	2. 49	0.33.40
				$\frac{1}{4}$	5. 37	0.25.40
				$\frac{3}{4}$	8. 26	0.33.44
				1	11. 15	0.45.00
				$1 \frac{1}{4}$	14. 04	
				$1 \frac{1}{2}$	16. 52	
				$1 \frac{3}{4}$	19. 41	
NNE.	SSE.	NNW.	SSW.	2	22. 30	1.30
				$2 \frac{1}{4}$	25. 19	
				$2 \frac{1}{2}$	28. 07	
				$2 \frac{3}{4}$	30. 56	
NEbN.	SEbS.	NWbN.	SWbS.	3	33. 45	2.15
				$3 \frac{1}{4}$	36. 34	
				$3 \frac{1}{2}$	39. 22	
				$3 \frac{3}{4}$	42. 11	
NEast.	SEast.	NWest.	SWest.	4	45. 00	3. 0
				$4 \frac{1}{4}$	47. 49	
				$4 \frac{1}{2}$	50. 38	
				$4 \frac{3}{4}$	53. 26	
NEbE.	SEbE.	NWbW.	SWbW.	5	56. 15	3.45
				$5 \frac{1}{4}$	59. 04	
				$5 \frac{1}{2}$	61. 53	
				$5 \frac{3}{4}$	64. 41	
ENE.	ESE.	WNW.	WSW.	6	67. 30	4.30
				$6 \frac{1}{4}$	70. 19	
				$6 \frac{1}{2}$	73. 08	
				$6 \frac{3}{4}$	75. 56	
EbN.	EbS.	WbN.	WbS.	7	78. 45	5.15
				$7 \frac{1}{4}$	81. 34	
				$7 \frac{1}{2}$	84. 23	
				$7 \frac{3}{4}$	87. 11	
East.	East.	West.	West.	8	90. 00	6. 0

No. c. A General TIDE-TABLE. N.B. at London, N.E. S.W.

Days.	N.E. & N. S.W. & S.		E. & S. W. & N.		S. & S.E. N.N.W.		N. and S.		E. & W.		E. & N. W. & S.		N.E. & E. S.W. & W.		E. & S.E. W. & N.W.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	3.	0	7.	33	11.	18	12.	48	6.	48	6.	3	4.	33	8.	18
2	3.	48	8.	21	12.	6	1.	36	7.	51	6.	51	5.	21	9.	6
3	4.	36	9.	9	12.	54	2.	24	8.	39	7.	39	6.	9	9.	54
4	5.	24	9.	57	1.	42	3.	12	9.	27	8.	27	6.	57	10.	42
5	6.	12	10.	45	2.	30	4.	0	10.	15	9.	15	7.	42	11.	30
6	7.	0	11.	33	3.	18	4.	48	11.	3	10.	3	8.	33	12.	18
7	7.	48	12.	21	4.	6	5.	36	11.	51	10.	51	9.	21	1.	6
8	8.	36	1.	9	4.	54	6.	24	12.	49	11.	39	10.	9	1.	54
9	9.	24	1.	57	5.	42	7.	12	1.	27	12.	27	10.	57	2.	42
10	10.	12	2.	45	6.	30	8.	0	2.	15	1.	15	11.	42	3.	30
11	11.	0	3.	33	7.	18	8.	4	3.	32.	3	12.	3	4.	18	
12	11.	48	4.	21	8.	6	9.	36	3.	51	2.	51	1.	21	5.	6
13	12.	36	5.	9	8.	54	10.	24	4.	39	3.	39	2.	9	5.	54
14	1.	24	5.	57	9.	42	11.	12	5.	27	4.	27	2.	57	6.	42
15	2.	12	6.	45	10.	30	12.	0	6.	15	5.	15	3.	42	7.	30
16	3.	0	7.	33	11.	18	0.	48	6.	48	6.	3	4.	33	8.	18
17	3.	48	8.	21	12.	6	1.	36	7.	51	6.	51	5.	21	9.	6
18	4.	36	9.	9	12.	54	2.	24	8.	39	7.	39	6.	9	9.	54
19	5.	24	9.	57	1.	42	3.	12	9.	27	8.	27	6.	57	10.	42
20	6.	1	10.	45	2.	30	4.	0	10.	15	9.	15	7.	42	11.	30
21	7.	0	11.	33	3.	18	4.	48	11.	3	10.	3	8.	33	12.	18
22	7.	48	12.	21	4.	6	5.	36	11.	51	10.	51	9.	21	1.	6
23	8.	36	1.	9	4.	54	6.	24	12.	49	11.	39	10.	9	1.	54
24	9.	24	1.	57	5.	42	7.	12	1.	27	12.	27	10.	57	2.	42
25	10.	12	2.	45	6.	30	8.	0	2.	15	1.	15	11.	42	3.	30
26	11.	0	3.	33	7.	18	8.	48	3.	32.	3	12.	3	4.	18	
27	11.	48	4.	21	8.	6	9.	36	3.	51	2.	51	1.	21	5.	6
28	12.	36	5.	9	8.	54	10.	24	4.	39	3.	39	2.	9	5.	54
29	1.	24	5.	57	9.	42	11.	12	5.	27	4.	27	2.	57	6.	42
30	12.	2	6.	45	10.	30	12.	0	6.	15	5.	15	3.	42	7.	30
Age.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.	H.	I.
	Amsterd. R. Hood's Bay. Denz. Lisbon.	S. Nicho- las. Foulness. At the Starts.	Solebay. Lystif. R. Graves. Mare's Road	Beachy. Kent-Kn The Nore Iste of Wight.	Antwer. Hamlo- rough. Off Sylly. Off Bours. Humber.	S. Male's-In R- Milford. Mounts- Bay. Lizard Spurn										
	N.E. & N. S.W. & S.	E. & S. W. & N.	S. & S.E. N.N.W.	N. and S.	E. and W.	E. & N. W. & S.	N.E. & E. S.W. & W.	S. & S.E. W. & N.W.								

Logarithm - Numbers		From 1, to 1020.	
1	0.0000000	1	0.0000000
2	0.3010300	2	0.3010300
3	0.4771213	3	0.4771213
4	0.6020600	4	0.6020600
5	0.6989700	5	0.6989700
6	0.7781513	6	0.7781513
7	0.8450980	7	0.8450980
8	0.9030900	8	0.9030900
9	0.9542425	9	0.9542425
10	1.0000000	10	1.0000000
11	1.0413927	11	1.0413927
12	1.0791812	12	1.0791812
13	1.1139433	13	1.1139433
14	1.1461280	14	1.1461280
15	1.1760913	15	1.1760913
16	1.2041199	16	1.2041199
17	1.2303714	17	1.2303714
18	1.2552725	18	1.2552725
19	1.2789344	19	1.2789344
20	1.3021310	20	1.3021310
21	1.3249215	21	1.3249215
22	1.3473742	22	1.3473742
23	1.3695581	23	1.3695581
24	1.3915421	24	1.3915421
25	1.4133866	25	1.4133866
26	1.4350618	26	1.4350618
27	1.4565478	27	1.4565478
28	1.4779257	28	1.4779257
29	1.4991766	29	1.4991766
30	1.5202915	30	1.5202915
31	1.5412614	31	1.5412614
32	1.5620772	32	1.5620772
33	1.5827398	33	1.5827398
34	1.6032501	34	1.6032501
35	1.6236090	35	1.6236090
36	1.6438174	36	1.6438174
37	1.6638762	37	1.6638762
38	1.6837863	38	1.6837863
39	1.7035486	39	1.7035486
40	1.7231640	40	1.7231640
41	1.7426334	41	1.7426334
42	1.7619577	42	1.7619577
43	1.7811378	43	1.7811378
44	1.8001736	44	1.8001736
45	1.8190660	45	1.8190660
46	1.8378159	46	1.8378159
47	1.8564242	47	1.8564242
48	1.8748918	48	1.8748918
49	1.8932196	49	1.8932196
50	1.9114085	50	1.9114085
51	1.9294594	51	1.9294594
52	1.9473732	52	1.9473732
53	1.9651508	53	1.9651508
54	1.9827931	54	1.9827931
55	2.0003010	55	2.0003010
56	2.0176754	56	2.0176754
57	2.0349172	57	2.0349172
58	2.0520273	58	2.0520273
59	2.0689966	59	2.0689966
60	2.0858260	60	2.0858260
61	2.1025164	61	2.1025164
62	2.1190687	62	2.1190687
63	2.1354838	63	2.1354838
64	2.1517626	64	2.1517626
65	2.1679060	65	2.1679060
66	2.1839149	66	2.1839149
67	2.1997892	67	2.1997892
68	2.2155298	68	2.2155298
69	2.2311376	69	2.2311376
70	2.2466135	70	2.2466135
71	2.2619584	71	2.2619584
72	2.2771732	72	2.2771732
73	2.2922588	73	2.2922588
74	2.3072161	74	2.3072161
75	2.3220460	75	2.3220460
76	2.3367494	76	2.3367494
77	2.3513272	77	2.3513272
78	2.3657785	78	2.3657785
79	2.3801042	79	2.3801042
80	2.3943053	80	2.3943053
81	2.4083828	81	2.4083828
82	2.4223366	82	2.4223366
83	2.4361667	83	2.4361667
84	2.4498740	84	2.4498740
85	2.4634585	85	2.4634585
86	2.4769202	86	2.4769202
87	2.4902590	87	2.4902590
88	2.5034758	88	2.5034758
89	2.5165705	89	2.5165705
90	2.5295440	90	2.5295440
91	2.5423972	91	2.5423972
92	2.5551310	92	2.5551310
93	2.5677453	93	2.5677453
94	2.5802400	94	2.5802400
95	2.5926150	95	2.5926150
96	2.6048702	96	2.6048702
97	2.6170056	97	2.6170056
98	2.6290212	98	2.6290212
99	2.6409169	99	2.6409169
100	2.6526926	100	2.6526926
101	2.6643492	101	2.6643492
102	2.6758867	102	2.6758867
103	2.6873050	103	2.6873050
104	2.6986041	104	2.6986041
105	2.7097840	105	2.7097840
106	2.7208446	106	2.7208446
107	2.7317858	107	2.7317858
108	2.7426075	108	2.7426075
109	2.7533096	109	2.7533096
110	2.7638921	110	2.7638921
111	2.7743550	111	2.7743550
112	2.7846982	112	2.7846982
113	2.7949217	113	2.7949217
114	2.8050254	114	2.8050254
115	2.8150092	115	2.8150092
116	2.8248730	116	2.8248730
117	2.8346167	117	2.8346167
118	2.8442403	118	2.8442403
119	2.8537438	119	2.8537438
120	2.8631272	120	2.8631272
121	2.8723905	121	2.8723905
122	2.8815336	122	2.8815336
123	2.8905565	123	2.8905565
124	2.8994592	124	2.8994592
125	2.9082416	125	2.9082416
126	2.9169036	126	2.9169036
127	2.9254452	127	2.9254452
128	2.9338663	128	2.9338663
129	2.9421668	129	2.9421668
130	2.9503467	130	2.9503467
131	2.9584060	131	2.9584060
132	2.9663446	132	2.9663446
133	2.9741625	133	2.9741625
134	2.9818596	134	2.9818596
135	2.9894358	135	2.9894358
136	2.9968911	136	2.9968911
137	3.0042254	137	3.0042254
138	3.0114387	138	3.0114387
139	3.0185309	139	3.0185309
140	3.0255020	140	3.0255020
141	3.0323520	141	3.0323520
142	3.0390808	142	3.0390808
143	3.0456884	143	3.0456884
144	3.0521748	144	3.0521748
145	3.0585400	145	3.0585400
146	3.0647839	146	3.0647839
147	3.0709065	147	3.0709065
148	3.0769078	148	3.0769078
149	3.0827878	149	3.0827878
150	3.0885465	150	3.0885465
151	3.0941839	151	3.0941839
152	3.0996990	152	3.0996990
153	3.1050918	153	3.1050918
154	3.1103623	154	3.1103623
155	3.1155104	155	3.1155104
156	3.1205361	156	3.1205361
157	3.1254393	157	3.1254393
158	3.1302200	158	3.1302200
159	3.1348781	159	3.1348781
160	3.1394136	160	3.1394136
161	3.1438264	161	3.1438264
162	3.1481165	162	3.1481165
163	3.1522839	163	3.1522839
164	3.1563285	164	3.1563285
165	3.1602503	165	3.1602503
166	3.1640492	166	3.1640492
167	3.1677251	167	3.1677251
168	3.1712780	168	3.1712780
169	3.1747079	169	3.1747079
170	3.1780148	170	3.1780148
171	3.1811987	171	3.1811987
172	3.1842596	172	3.1842596
173	3.1871974	173	3.1871974
174	3.1900121	174	3.1900121
175	3.1927036	175	3.1927036
176	3.1952719	176	3.1952719
177	3.1977170	177	3.1977170
178	3.2000399	178	3.2000399
179	3.2022396	179	3.2022396
180	3.2043161	180	3.2043161
181	3.2062694	181	3.2062694
182	3.2080995	182	3.2080995
183	3.2097963	183	3.2097963
184	3.2113698	184	3.2113698
185	3.2128199	185	3.2128199
186	3.2141466	186	3.2141466
187	3.2153499	187	3.2153499
188	3.2164298	188	3.2164298
189	3.2173863	189	3.2173863
190	3.2182294	190	3.2182294
191	3.2189591	191	3.2189591
192	3.2195754	192	3.2195754
193	3.2200782	193	3.2200782
194	3.2205675	194	3.2205675
195	3.2209432	195	3.2209432
196	3.2212053	196	3.2212053
197	3.2214538	197	3.2214538
198	3.2216877	198	3.2216877
199	3.2218070	199	3.2218070
200	3.2218117	200	3.2218117

N.	Logarith.	N.	Logarith.	N.	Logarith.
1	0.000000	35	1.544068	69	1.838849
2	0.301030	36	1.556303	70	1.845098
3	0.477121	37	1.568202	71	1.851258
4	0.602060	38	1.579783	72	1.857332
5	0.698970	39	1.591064	73	1.863323
6	0.778151	40	1.602060	74	1.869222
7	0.845098	41	1.612784	75	1.875061
8	0.903090	42	1.623249	76	1.880813
9	0.954242	43	1.633468	77	1.886491
10	1.100000	44	1.643452	78	1.892094
11	1.041393	45	1.653212	79	1.897627
12	1.079181	46	1.662758	80	1.903090
13	1.113943	47	1.672098	81	1.908485
14	1.146128	48	1.681241	82	1.913814
15	1.176091	49	1.690196	83	1.919078
16	1.204120	50	1.698990	84	1.924279
17	1.230449	51	1.707570	85	1.929419
18	1.255272	52	1.716003	86	1.934498
19	1.278753	53	1.724276	87	1.939519
20	1.301230	54	1.732394	88	1.944482
21	1.322219	55	1.740362	89	1.949390
22	1.342422	56	1.748188	90	1.954242
23	1.361728	57	1.755875	91	1.959041
24	1.380211	58	1.763428	92	1.963788
25	1.397940	59	1.770852	93	1.968483
26	1.414973	60	1.778151	94	1.973128
27	1.431364	61	1.785330	95	1.977723
28	1.447121	62	1.792391	96	1.982271
29	1.462398	63	1.799340	97	1.986772
30	1.477121	64	1.806180	98	1.991226
31	1.491361	65	1.812913	99	1.995635
32	1.505150	66	1.819544	100	2.000000
33	1.518514	67	1.826075	101	2.004321
34	1.531479	68	1.832509	102	2.008600

N.	Logarith.	N.	Logarith.	N.	Logarith.
103	2.012837	137	2.136721	171	2.232996
104	2.017033	138	2.139879	172	2.235528
105	2.021189	139	2.143015	173	2.238046
106	2.025306	140	2.146128	174	2.240549
107	2.029284	141	2.159219	175	2.243038
108	2.033424	142	2.152288	176	2.245513
109	2.037426	143	2.155336	177	2.247973
110	2.041393	144	2.158362	178	2.250420
111	2.045323	145	2.161368	179	2.252853
112	2.049218	146	2.164353	180	2.255273
113	2.053078	147	2.167317	181	2.257679
114	2.056905	148	2.170262	182	2.260071
115	2.060698	149	2.173186	183	2.262451
116	2.064458	150	2.176091	184	2.264818
117	2.068186	151	2.178977	185	2.267172
118	2.071882	152	2.181844	186	2.269513
119	2.075547	153	2.184691	187	2.271842
120	2.079181	154	2.187521	188	2.274158
121	2.082785	155	2.190332	189	2.276462
122	2.086359	156	2.193125	190	2.278754
123	2.089905	157	2.195899	191	2.281033
124	2.093422	158	2.198657	192	2.283301
125	2.096010	159	2.201397	193	2.285557
126	2.100371	160	2.204110	194	2.285802
127	2.103804	161	2.209826	195	2.290035
128	2.107200	162	2.209515	196	2.292256
129	2.110589	163	2.212187	197	2.294466
130	2.113942	164	2.214844	198	2.296665
131	2.117271	165	2.217484	199	2.298853
132	2.120574	166	2.220108	200	2.301029
133	2.123582	167	2.222716	201	2.303196
134	2.127105	168	2.225309	202	2.305351
135	2.130334	169	2.227887	203	2.307496
136	2.133539	170	2.230449	204	2.309630

N.	Logarith.	N.	Logarith.	N.	Logarith.
205	2.311754	239	2.378398	273	2.436163
206	2.313867	240	2.380211	274	2.437751
207	2.315970	241	2.382017	275	2.439333
208	2.318063	242	2.383815	276	2.440909
209	2.320146	243	2.385606	277	2.442479
210	2.322219	244	2.387289	278	2.444045
211	2.324282	245	2.389166	279	2.445604
212	2.326336	246	2.390935	280	2.447158
213	2.328379	247	2.392697	281	2.448706
214	2.330414	248	2.394452	272	2.450249
215	2.332438	249	2.326199	283	2.451786
216	2.334454	250	2.397940	284	2.453318
217	2.336459	251	2.399674	285	2.454845
218	2.338456	252	2.401401	286	2.456366
219	2.340444	253	2.403121	287	2.457889
220	2.342422	254	2.404834	288	2.459362
221	2.344392	255	2.406540	289	2.460898
222	2.346353	256	2.408239	290	2.462398
223	2.348305	257	2.409933	291	2.463893
224	2.350248	258	2.411619	292	2.465383
225	2.352183	259	2.413299	293	2.466868
226	2.354108	260	2.414973	294	2.468347
227	2.356026	261	2.416641	295	2.469822
228	2.357935	262	2.418301	296	2.471292
229	2.359835	263	2.419956	297	2.472756
230	2.361728	264	2.421604	298	2.474216
231	2.363612	265	2.423246	299	2.575671
232	2.365488	266	2.424882	300	2.477121
233	2.367356	267	2.426511	301	2.478566
234	2.369216	268	2.428135	302	2.480007
235	2.371068	269	2.429752	303	2.481443
236	2.372912	270	2.431364	304	2.482874
237	2.374748	271	2.432969	305	2.484299
238	2.376577	272	2.434569	306	2.485721

A Table of Logarithms.

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N.	Logarith.	N.	Logarith.	N.	Logarith.
307	2.487133	341	2.532754	375	2.574031
308	2.488151	342	2.534026	376	2.575188
309	2.489958	343	2.535294	377	2.576341
310	2.491362	344	2.536558	378	2.577493
311	2.492760	345	2.537819	379	2.578649
312	2.494155	346	2.539076	380	2.579784
313	2.495544	347	2.540329	381	2.580925
314	2.496929	348	2.541579	382	2.582063
315	2.498311	349	2.542825	383	2.583199
316	2.499687	350	2.544066	384	2.584331
317	2.501059	351	2.545307	385	2.585461
318	2.502427	352	2.546543	386	2.586587
319	2.503791	353	2.547775	387	2.587711
320	2.505149	354	2.549003	388	2.588832
321	2.506505	355	2.550228	389	2.589949
322	2.507856	356	2.551449	390	2.591065
323	2.509203	357	2.552668	391	2.592177
324	2.510545	358	2.553883	392	2.593286
325	2.511883	359	2.555094	393	2.594393
326	2.513218	360	2.556303	394	2.595496
327	2.514548	361	2.557507	395	2.596597
328	2.515874	362	2.558709	396	2.597695
329	2.517196	363	2.559907	397	2.598790
330	2.518514	364	2.561101	398	2.599883
331	2.519828	365	2.562293	399	2.600973
332	2.521138	366	2.563481	400	2.602059
333	2.522444	367	2.564666	401	2.603144
334	2.523746	368	2.565848	402	2.604226
335	2.525045	369	2.567026	403	2.605305
336	2.526339	370	2.568202	404	2.606381
337	2.527629	371	2.569374	405	2.607455
338	2.528916	372	2.570543	406	2.608526
339	2.530199	373	2.571709	407	2.609594
340	2.531479	374	2.572872	408	2.610660

N	Logarith	N	Logarith	N	Logarith
409	2.611723	443	2.646404	477	2.678518
410	2.612784	444	2.647383	478	2.679428
411	2.613842	445	2.648360	479	2.680336
412	2.614897	446	2.649335	480	2.681241
413	2.615950	447	2.650308	481	2.682145
414	2.617000	448	2.651278	482	2.683047
415	2.618048	449	2.652246	483	2.683947
416	2.619093	450	2.653213	484	2.684845
417	2.620136	451	2.654177	485	2.685742
418	2.621176	452	2.655138	486	2.686636
419	2.622214	453	2.656098	487	2.687529
420	2.623249	454	2.657056	488	2.688419
421	2.624282	455	2.658011	489	2.689309
422	2.625312	456	2.658965	490	2.690196
423	2.626340	457	2.659916	491	2.691081
424	2.627366	458	2.660865	492	2.691965
425	2.628389	459	2.661813	493	2.692847
426	2.629409	460	2.662758	494	2.693727
427	2.630428	461	2.663642	495	2.694605
428	2.631444	462	2.664643	496	2.695482
429	2.632457	463	2.665581	497	2.696356
430	2.633468	464	2.666518	498	2.697229
431	2.634477	465	2.667453	499	2.698101
432	2.635484	466	2.668386	500	2.698970
433	2.636488	467	2.669317	501	2.699838
434	2.637489	468	2.670246	502	2.700704
435	2.638489	469	2.671173	503	2.701568
436	2.639486	470	2.672098	504	2.702430
437	2.640481	471	2.673021	505	2.703291
438	2.641475	472	2.673942	506	2.704151
439	2.642465	473	2.674861	507	2.705008
440	2.643453	474	2.675778	508	2.705863
441	2.644439	475	2.676694	509	2.706718
442	2.645422	476	2.677607	510	2.707570

A Table of Logarithms.

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N.	Logarith.	N.	Logarith.	N.	Logarith.
511	2.708421	545	2.736397	579	2.762679
512	2.709269	546	2.737192	580	2.763428
513	2.710117	547	2.737987	581	2.764176
514	2.710963	548	2.738781	582	2.764923
515	2.711807	549	2.739572	583	2.765669
516	2.712649	550	2.740363	584	2.766413
517	2.713491	551	2.741152	585	2.767156
518	2.714329	552	2.741939	586	2.767898
519	2.715167	553	2.742725	587	2.768638
520	2.716003	554	2.743509	588	2.769377
521	2.716838	555	2.744293	589	2.770115
522	2.717671	556	2.745075	590	2.770852
523	2.718502	557	2.745855	591	2.771587
524	2.719331	558	2.746634	592	2.772322
525	2.720159	559	2.747412	593	2.773055
526	2.720986	560	2.748188	594	2.773786
527	2.721811	561	2.748963	595	2.774519
528	2.722634	562	2.749736	596	2.775246
529	2.723456	563	2.750508	597	2.775974
530	2.724276	564	2.751279	598	2.776701
531	2.725095	565	2.752048	599	2.777427
532	2.725912	566	2.752816	600	2.778151
533	2.726727	567	2.753583	601	2.778874
534	2.727541	568	2.754348	602	2.779596
535	2.728354	569	2.755112	603	2.780317
536	2.729169	570	2.755875	604	2.781037
537	2.729974	571	2.756636	605	2.781755
538	2.730782	572	2.757396	606	2.782473
539	2.731589	573	2.758155	607	2.783189
540	2.732394	574	2.758912	608	2.783904
541	2.733197	575	2.759668	609	2.784617
542	2.733999	576	2.760422	610	2.785329
543	2.734799	577	2.761176	611	2.786041
544	2.735599	578	2.761928	612	2.786751

N.	Logarith.	N.	Logarith.	N.	Logarith.
613	2.787460	647	2.810904	681	2.833147
614	2.788164	648	2.811575	682	2.833784
615	2.788875	649	2.812245	683	2.834421
616	2.789581	650	2.812913	684	2.835056
617	2.790285	651	2.813581	685	2.835691
618	2.790988	652	2.814248	686	2.836324
619	2.791691	653	2.814913	687	2.836957
620	2.792392	654	2.815578	688	2.837588
621	2.793092	655	2.816241	689	2.838219
622	2.793791	656	2.816904	690	2.838849
623	2.794488	657	2.817565	691	2.839478
624	2.795185	658	2.818226	692	2.840106
625	2.795880	659	2.818885	693	2.840733
626	2.796574	660	2.819543	694	2.841359
627	2.797268	661	2.820201	695	2.841985
628	2.797959	662	2.820858	696	2.842609
629	2.798651	663	2.821514	697	2.843233
630	2.799341	664	2.822168	698	2.843855
631	2.800029	665	2.822822	699	2.844477
632	2.800717	666	2.823474	700	2.845098
633	2.801404	667	2.824126	701	2.845718
634	2.802089	668	2.824776	702	2.846337
635	2.802774	669	2.825426	703	2.846955
636	2.803457	670	2.826075	704	2.847573
637	2.80413	671	2.826723	705	2.848189
638	2.804821	672	2.827369	706	2.848805
639	2.805501	673	2.828015	707	2.849419
640	2.806179	674	2.828659	708	2.850033
641	2.806858	675	2.829304	709	2.850646
642	2.807535	676	2.829947	710	2.851258
643	2.808211	677	2.830589	711	2.851869
644	2.808886	678	2.831229	712	2.852479
645	2.809559	679	2.831869	713	2.853089
649	2.810904	680	2.832509	714	2.853698

Table of Logarithms.

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N.	Logarith.	N.	Logarith.	N.	Logarith.
715	2.854306	749	2.874482	783	2.893762
716	2.8544013	750	2.875062	784	2.894310
717	2.855539	751	2.875639	785	2.894869
718	2.856124	752	2.876218	786	2.895422
719	2.856729	753	2.876795	787	2.895975
720	2.857332	754	2.877371	788	2.896526
721	2.857935	755	2.877947	789	2.897077
722	2.858537	756	2.878522	790	2.897627
723	2.859138	757	2.879096	791	2.898176
724	2.859739	758	2.879669	792	2.898725
725	2.860338	759	2.880242	793	2.899273
726	2.860937	760	2.880814	794	2.899821
727	2.861534	761	2.881385	795	2.900367
728	2.862131	762	2.881955	796	2.900912
729	2.862728	763	2.882525	797	2.901458
730	2.863323	764	2.883093	798	2.902002
731	2.863917	765	2.883661	799	2.902547
732	2.864511	766	2.884229	800	2.903090
733	2.865104	767	2.884795	801	2.903633
734	2.865696	768	2.885361	802	2.904174
735	2.866287	769	2.885926	803	2.904716
736	2.866878	770	2.886491	804	2.905256
737	2.867467	771	2.887054	805	2.905796
738	2.868056	772	2.887617	806	2.906335
739	2.868643	773	2.888179	807	2.906874
740	2.869232	774	2.888741	808	2.907411
741	2.869818	775	2.889302	809	2.907949
742	2.870404	776	2.889862	810	2.908485
743	2.870989	777	2.890421	811	2.909020
744	2.871573	778	2.890979	812	2.909556
745	2.872156	779	2.891537	813	2.910090
746	2.872739	780	2.892095	814	2.910624
747	2.873321	781	2.892651	815	2.911158
748	2.873902	782	2.893207	816	2.911690

N.	Logarith.	N.	Logarith.	N.	Logarith.
817	2.912222	851	2.929929	885	2.946943
818	2.912753	852	2.930439	886	2.947434
819	2.913284	853	2.930949	887	2.947924
820	2.913814	854	2.931456	888	2.948413
821	2.914343	855	2.931966	889	2.948902
822	2.914872	856	2.932474	890	2.949390
823	2.915399	857	2.932981	891	2.949878
824	2.915927	858	2.933487	892	2.950365
825	2.916454	859	2.933993	893	2.950851
826	2.916980	860	2.934498	894	2.951338
827	2.917506	861	2.935003	895	2.951823
828	2.918035	862	2.935507	896	2.952308
829	2.918560	863	2.936011	897	2.952792
830	2.919078	864	2.936514	898	2.953276
831	2.919598	865	2.937016	899	2.953759
832	2.920113	866	2.937518	900	2.954243
833	2.920645	867	2.938019	901	2.954725
834	2.921166	868	2.938519	902	2.955207
835	2.921686	869	2.939019	903	2.955688
836	2.922206	870	2.939519	904	2.956168
837	2.922725	871	2.940018	905	2.956649
838	2.923244	872	2.940516	906	2.957128
839	2.923762	873	2.941014	907	2.957607
840	2.924276	874	2.941511	908	2.958086
841	2.924797	875	2.942004	909	2.958564
842	2.925313	876	2.942508	910	2.959041
843	2.925828	877	2.942999	911	2.959518
844	2.926342	878	2.943495	912	2.959995
845	2.926857	879	2.943989	913	2.960471
846	2.927370	880	2.944483	914	2.960946
847	2.927883	881	2.944976	915	2.961401
848	2.928396	882	2.945468	916	2.961895
849	2.928908	883	2.945961	917	2.962369
850	2.929419	884	2.946452	918	2.962840

A Table of Logarithms.

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N.	Logarith.	N.	Logarith.	N.	Logarith.
919	2.963315	953	2.979093	987	2.994317
920	2.963788	954	2.979548	988	2.994756
921	2.964259	955	2.980003	989	2.995196
922	2.964731	956	2.980458	990	2.995635
923	2.965202	957	2.980912	991	2.996074
924	2.965672	958	2.981365	992	2.996512
925	2.966142	959	2.981819	993	2.996949
926	2.966611	960	2.982271	994	2.997386
927	2.967079	961	2.982723	995	2.997823
928	2.967548	962	2.983175	996	2.998259
929	2.968016	963	2.983626	997	2.998695
930	2.968483	964	2.984077	998	2.999133
931	2.968949	965	2.984527	999	2.999565
932	2.969416	966	2.984977	1000	3.000000
933	2.969884	967	2.985426	1001	3.000434
934	2.970347	968	2.985875	1002	3.000868
935	2.970812	969	2.986324	1003	3.001301
936	2.971276	970	2.986772	1004	3.001734
937	2.971739	971	2.987219	1005	3.002166
938	2.972203	972	2.987666	1006	3.002598
939	2.972666	973	2.988113	1007	3.003029
940	2.973128	974	2.988559	1008	3.003460
941	2.973589	975	2.989005	1009	3.003891
942	2.974050	976	2.989449	1010	3.004321
943	2.974512	977	2.989895	1011	3.004751
944	2.974972	978	2.990339	1012	3.005180
945	2.975432	979	2.990783	1013	3.005609
946	2.975891	980	2.991226	1014	3.006038
947	2.976349	981	2.991669	1015	3.006466
948	2.976808	982	2.992111	1016	3.006894
949	2.977266	983	2.992554	1017	3.007321
950	2.977724	984	2.992995	1018	3.007748
951	2.978181	985	2.993436	1019	3.008174
952	2.978637	986	2.993877	1020	3.008600

272 (N^o. 7.) *A Table of Natural and Logarithmetick
Sines and Tangents.*

D.	N. Sine	N. Tan	Log. Sine.	Log Tang.	Log Secant.
1	1745	1746	8.241855	8.241921	10.000068
2	3490	3492	8.542819	8.543082	10.000269
3	5234	5241	8.718800	8.719395	10.000602
4	6976	6993	8.843555	8.844543	10.001068
5	8716	8749	8.940296	8.941951	10.001656
6	10453	10510	9.019234	9.021620	10.002386
7	12187	12278	9.085894	9.089143	10.003249
8	13917	14054	9.143555	9.147802	10.004247
9	15643	15838	9.194332	9.199712	10.005380
10	17365	17633	9.239670	9.246318	10.006648
11	19084	19438	9.280598	9.288652	10.008053
12	20791	21259	9.317878	9.327474	10.009596
13	22495	23087	9.352088	9.363364	10.011276
14	24192	24933	9.383675	9.396771	10.013096
15	25882	26795	9.413096	9.428052	10.015056
16	27564	28675	9.440338	9.457496	10.017158
17	29237	30573	9.465935	9.485339	10.019404
18	30902	32492	9.489982	9.511776	10.021794
19	32557	34433	9.512641	9.536971	10.024330
20	34202	36397	9.534051	9.561065	10.027014
21	35837	38386	9.554329	9.584177	10.029848
22	37461	40403	9.573375	9.606406	10.032834
23	39073	42447	9.591878	9.627851	10.035974
24	40674	44523	9.591878	9.648583	10.039270
25	42262	46631	9.609313	9.668672	10.042724
26	43837	48773	9.641842	9.688181	10.046340
27	45399	50953	9.657016	9.707165	10.050119
28	46947	53171	9.671609	9.725674	10.054065
29	48481	55431	9.685571	9.743752	10.058181
30	50000	57735	9.698970	9.761439	10.060469

A Table of Natural and Logarithmetick 273
Sines and Tangents.

D.	N. Sine	N. Tan.	Log. Sine.	Log. Tang.	Log. Secant
31	51504	60086	9.711839	9.778773	10.066934
32	52992	62487	9.724209	9.795789	10.071579
33	54464	64941	9.736108	9.812517	10.076409
34	55919	67451	9.747561	9.828987	10.081426
35	57358	70021	9.758591	9.845226	10.086635
36	58779	72654	9.769218	9.861261	10.092042
37	60181	75355	9.779463	9.877114	10.097651
38	61566	78129	9.789342	9.892809	10.103468
39	62932	80978	9.798871	9.908369	10.109497
40	64279	83910	9.808067	9.923813	10.115746
41	65606	86929	9.816942	9.939163	10.122220
42	66913	90040	9.825510	9.954437	10.128926
43	68200	93252	9.833783	9.969655	10.135872
44	69466	96569	9.841771	9.984837	10.143066
45	70711	100000	9.849485	10.000000	10.150515
46	71934	103553	9.856934	10.015162	10.158229
47	73133	107237	9.864127	10.030344	10.166217
48	74314	111061	9.871073	10.045562	10.174489
49	75471	115037	9.877779	10.060836	10.183057
50	76604	119175	9.884254	10.076186	10.191932
51	77715	123490	9.890502	10.091630	10.201128
52	78801	127994	9.896532	10.107190	10.210658
53	79864	132704	9.902348	10.122885	10.220537
54	80902	137638	9.907957	10.138739	10.230781
55	81915	142815	9.913364	10.154773	10.241409
56	82904	148256	9.918574	10.171012	10.252438
57	83867	153986	9.923591	10.187482	10.263891
58	84805	160033	9.928420	10.204210	10.275790
59	85717	166428	9.933065	10.221226	10.288161
60	86603	173205	9.937530	10.238560	10.301030

*A Table of Natural and Logarithmetick
Sines and Tangents.*

D.	N. Sine	N. Tang.	Log. Sine.	Log. Tang.	Log. Secant.
61	87462	180405	9.941818	10.256248	10.314429
62	88295	188073	9.945934	10.274325	10.328391
63	89101	196261	9.949881	10.292834	10.342953
64	89879	205030	9.953660	10.311818	10.358158
65	90631	214451	9.957275	10.331327	10.374052
66	91355	224604	9.960730	10.351416	10.390687
67	92050	235585	9.964026	10.372148	10.408122
68	92718	247309	9.967166	10.393590	10.426425
69	93358	260509	9.970151	10.415822	10.445671
70	93969	274748	9.972985	10.438934	10.465948
71	94552	290421	9.975670	10.463028	10.487358
72	95106	307768	9.978206	10.488224	10.510018
73	95630	327085	9.980596	10.514661	10.534065
74	96126	348741	9.982841	10.542503	10.559662
75	96593	373205	9.984943	10.571947	10.587004
76	97030	401078	9.986904	10.603228	10.616325
77	97437	433148	9.988723	10.636635	10.647912
78	97815	470463	9.990404	10.672525	10.682121
79	98163	514455	9.991946	10.711347	10.719401
80	98481	567128	9.993351	10.753681	10.760330
81	98769	631375	9.994619	10.800287	10.805668
82	99027	711537	9.995752	10.852197	10.856445
83	99255	814435	9.996750	10.910856	10.914105
84	99452	951436	9.997614	10.978379	10.980765
85	99619	1143005	9.998344	11.058048	11.059704
86	99756	1430067	9.998940	11.1555356	11.156415
87	99863	1908114	9.999404	11.280604	11.281200
88	99939	2863625	9.999735	11.456916	11.457181
89	99985	5728996	9.999953	11.758078	11.758145
90	100000	Infinite.	10.000000	Infinite.	Infinite.

N^o 17 A Table of Sines, Tangents and Secants, 275
to each Point and Quarter-Point.

P.	N.Sine	N.Tan	Log. Sine.	Log. Tang.	Log. Sec.
I.	49	49	8.688863	8.669381	10.006519
2	98	98	8.990660	8.992750	10.002090
3	147	148	9.165454	9.170157	10.004703
I.	195	199	9.290236	9.298662	10.008426
1	243	250	9.385697	9.398919	10.013222
2	290	303	9.465032	9.482167	10.019134
3	337	358	9.527400	9.553548	10.026148
II.	383	414	9.582840	9.617224	10.034385
1	428	473	9.631059	9.674910	10.043852
2	471	534	9.673505	9.728109	10.054604
3	515	599	9.710997	9.777628	10.066631
III.	555	668	9.744739	9.824893	10.080154
1	596	742	9.775070	9.870265	10.095196
2	634	820	9.802435	9.914560	10.111866
3	671	906	9.827049	9.957231	10.130182
IV.	707	1000	9.849485	10.000000	10.150515
1	741	1103	9.869933	10.042769	10.172951
2	773	1218	9.888133	10.085698	10.197564
3	803	1348	9.904804	10.129735	10.224930
V.	831	1496	9.919846	10.175107	10.255261
1	858	1668	9.933369	10.222372	10.289214
2	882	1870	9.945396	10.271891	10.326495
3	904	2188	9.956148	10.325089	10.368941
VI.	924	2414	9.965615	10.382776	10.417160
1	941	2795	9.973852	10.446452	10.472600
2	957	3249	9.980866	10.517833	10.536968
3	970	3991	9.986778	10.601081	10.614303
VII.	981	5112	9.991574	10.701338	10.709764
1	989	6749	9.995278	10.828971	10.833693
2	995	10138	9.997897	11.005955	11.008057
3	999	20205	9.999475	11.308037	11.308562
VIII.	1000	Infinite	10.010000	Infinite.	Infinite.

N.	Squ.	N.	Squ.	N.	Squ.	N.	Squ.	N.	Squ.	N.	Squ.
1	1	31	961	61	3721	91	8281	121	14641	151	22801
2	4	32	1024	62	3844	92	8464	122	14884	152	23104
3	9	33	1089	63	3969	93	8649	123	15129	153	23409
4	16	34	1156	64	4096	94	8836	124	15376	154	23716
5	25	35	1225	65	4225	95	9025	125	15625	155	24025
6	36	36	1296	66	4356	96	9216	126	15876	156	24336
7	49	37	1369	67	4489	97	9409	127	16129	157	24649
8	64	38	1444	68	4624	98	9604	128	16384	158	24964
9	81	39	1521	69	4761	99	9801	129	16641	159	25281
10	100	40	1600	70	4900	100	10000	130	16900	160	25600
11	121	41	1681	71	5041	101	10201	131	17161	161	25921
12	144	42	1764	72	5184	102	10404	132	17424	162	26244
13	169	43	1849	73	5329	103	10609	133	17689	163	26569
14	196	44	1936	74	5476	104	10816	134	17956	164	26896
15	225	45	2025	75	5625	105	11025	135	18225	165	27225
16	256	46	2116	76	5776	106	11236	136	18496	166	27556
17	289	47	2209	77	5929	107	11449	137	18769	167	27889
18	324	48	2304	78	6084	108	11664	138	19044	168	28224
19	361	49	2401	79	6241	109	11881	139	19321	169	28561
20	400	50	2500	80	6400	110	12100	140	19600	170	28900
21	441	51	2601	81	6561	111	12321	141	19881	171	29241
22	484	52	2704	82	6724	112	12544	142	20164	172	29584
23	529	53	2809	83	6889	113	12769	143	20449	173	29929
24	576	54	2916	84	7056	114	12996	144	20736	174	30276
25	625	55	3025	85	7225	115	13225	145	21025	175	30625
26	676	56	3136	86	7396	116	13456	146	21316	176	30976
27	729	57	3249	87	7569	117	13689	147	21609	177	31329
28	784	58	3364	88	7744	118	13924	148	21904	178	31684
29	841	59	3481	89	7921	119	14161	149	22201	179	32041
30	900	60	3600	90	8100	120	14400	150	22500	180	32400

A Table of Square Numbers.

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N.	Squa.	N.	Squa.	N.	Squa.	N.	Squa.	N.	Squa.
181	32761	211	44521	241	58081	271	73441	301	90601
182	33124	212	44944	242	58564	272	73984	302	91204
183	33489	213	45369	243	59049	273	74529	303	91809
184	33856	214	45796	244	59536	274	75076	304	92416
185	34225	215	46225	245	60025	275	75625	305	93025
186	34596	216	46656	246	60516	276	76176	306	93636
187	34969	217	47089	247	61009	277	76729	307	94249
188	35344	218	47524	248	61504	278	77284	308	94864
189	35721	219	47961	249	62001	279	77841	309	95481
190	36100	220	48400	250	62500	280	78400	310	96100
191	36481	221	48841	251	63001	281	78961	311	96721
192	36864	222	49284	252	63504	282	79524	312	97344
193	37249	223	49729	253	64009	283	80089	313	97969
194	37636	224	50176	254	64516	284	80656	314	98596
195	38025	225	50625	255	65025	285	81225	315	99225
196	38416	226	51076	256	65536	286	81796	316	99856
197	38809	227	51529	257	66049	287	82369	317	100489
198	39204	228	51984	258	66564	288	82944	318	101124
199	39601	229	52441	259	67081	289	83521	319	101761
200	40000	230	52900	260	67600	290	84100	320	102400
201	40401	231	53361	261	68121	291	84681	321	103041
202	40804	232	53824	262	68644	292	85264	322	103684
203	41209	233	54289	263	69169	293	85849	323	104329
204	41616	234	54756	264	69696	294	86436	324	104976
205	42025	235	55225	265	70225	295	87025	325	105625
206	42436	236	55696	266	70756	296	87616	326	106276
207	42849	237	56169	267	71289	297	88209	327	106929
208	43264	238	56644	268	71824	298	88804	328	107584
209	43681	239	57121	269	72361	299	89401	329	108241
210	44100	240	57600	270	72900	300	90000	330	108900

N^o. 9. A Traverse-Table in Points and Quarters.

Dist.	$\frac{1}{4}$ Point.		$\frac{1}{2}$ Point.		$\frac{3}{4}$ Point.		1 Point.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	00	00	01	00	01	00	01	00	1
2	01	01	02	00	02	00	02	00	2
3	02	02	03	00	03	00	03	00	3
4	03	03	04	00	04	00	04	00	4
5	04	04	05	00	05	00	05	00	5
6	05	05	06	00	06	00	06	00	6
7	06	06	07	00	07	00	07	00	7
8	07	07	08	00	08	00	08	00	8
9	08	08	09	00	09	00	09	00	9
10	09	09	10	00	10	00	10	00	10
15	14	14	14	01	14	01	14	01	15
20	19	19	19	02	19	02	19	02	20
25	24	24	24	03	24	03	24	03	25
30	29	29	29	04	29	04	29	04	30
35	34	34	34	05	34	05	34	05	35
40	39	39	39	06	39	06	39	06	40
45	44	44	44	07	44	07	44	07	45
50	49	49	49	08	49	08	49	08	50
55	54	54	54	09	54	09	54	09	55
60	59	59	59	10	59	10	59	10	60
70	69	69	69	11	69	11	69	11	70
80	79	79	79	12	79	12	79	12	80
90	89	89	89	13	89	13	89	13	90
100	99	99	99	14	99	14	99	14	100
200	199	199	199	019	197	329	196	239	200
300	299	299	298	529	296	744	294	358	300
400	399	399	398	039	395	658	392	478	400
500	499	499	497	549	494	573	490	597	500
Dist.	$7\frac{1}{4}$ Point.		$7\frac{1}{2}$ Point.		$7\frac{3}{4}$ Point.		7 Points.		C.M.L.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	

A Traverse Table in Points and Quarters. 279

Dist.	1 $\frac{1}{2}$ Point.		1 $\frac{1}{4}$ Point.		1 $\frac{3}{4}$ Point.		2 Points.		C.M.L.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Di.	Lon	
1	1	00	2	1	00	3	0	90	4	1	
2	1	90	5	1	90	6	1	90	7	1	
3	2	90	7	2	90	9	2	81	1	3	
4	3	91	0	3	81	2	3	81	4	3	
5	4	81	2	4	81	5	4	71	5	4	
6	5	81	5	5	81	7	5	61	9	5	
7	6	81	7	6	72	0	6	52	3	6	
8	7	81	9	7	72	0	6	42	7	7	
9	8	72	2	8	62	0	6	43	1	8	
10	9	72	4	9	62	0	8	33	4	9	
15	14	53	6	14	44	4	9	23	8	10	
20	19	44	9	19	35	8	13	15	7	15	
25	24	26	0	23	17	3	18	9	6	20	
30	29	17	3	28	8	7	23	1	6	25	
35	33	9	5	33	10	2	27	11	5	30	
40	38	8	7	38	11	6	32	13	4	35	
45	43	6	9	43	13	1	36	15	3	40	
50	48	5	12	47	14	5	41	17	2	45	
55	53	3	13	45	16	0	46	19	1	50	
60	58	2	14	6	17	4	50	21	0	55	
70	67	9	17	0	20	3	55	23	0	60	
80	77	6	19	4	23	2	64	26	8	70	
90	87	3	21	9	26	1	73	30	6	80	
100	97	0	24	3	29	0	83	34	4	90	
200	194	0	48	6	191.4	58	0	188.4	67	4	100
300	291	0	72	9	287.1	87	0	282.6	101.1	277.2	200
400	388	0	97	2	382.8	116.0	0	376.8	134.8	369.6	300
500	485	0	121	5	478.5	145.0	0	471.0	168.5	462.0	400
										191.5	500
Dist.	6 $\frac{1}{4}$ Point.		6 $\frac{1}{2}$ Point.		6 $\frac{3}{4}$ Point.		6 Points.		C.M.L.		
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Di.	Lon	
1	6	3	6	3	6	3	6	3	1		

Dit.	2 $\frac{1}{2}$ Point.				2 $\frac{3}{4}$ Point.				3 Points.				C.M.L Di. Lon
	Lat.		Dep.		Lat.		Dep.		Lat.		Dep.		
1	0.	90	0	40	90	5	0	90	5	0	80	6	1
2	1.	80	0	91	80	9	1	71	0	1	71	1	2
3	2.	71	3	2	61	4	2	61	5	2	51	7	3
4	3.	61	7	3	51	9	3	42	1	3	32	2	4
5	4.	52	1	4	42	4	4	32	6	4	22	8	5
6	5.	42	6	5	32	8	5	13	1	5	03	3	6
7	6.	33	0	6	23	3	6	03	6	5	83	9	7
8	7.	23	4	7	13	8	6	94	1	6	64	4	8
9	8.	13	8	7	94	2	7	74	6	7	55	0	9
10	9.	04	3	8	84	7	8	65	1	8	35	6	10
15	13.	66	4	13	27	1	12	97	7	12	58	3	15
20	18.	18	5	17	69	4	17	110	3	16	611	1	20
25	22.	610	7	22	011	8	21	412	8	20	713	9	25
30	27.	112	8	26	514	1	25	715	1	24	916	7	30
35	31.	615	0	30	916	5	30	018	0	29	119	4	35
40	36.	217	1	35	318	9	34	320	6	33	322	2	40
45	40.	719	2	39	721	2	38	623	1	37	425	0	45
50	45.	221	4	44	123	6	40	925	7	41	627	8	50
55	49.	723	5	48	525	9	47	228	3	45	730	6	55
60	54.	225	9	52	928	3	51	530	8	49	933	3	60
70	63.	329	6	61	733	0	60	036	0	58	238	9	70
80	72.	334	2	70	537	7	68	641	1	66	544	4	80
90	81.	438	5	79	442	5	77	246	3	74	850	0	90
100	90.	442	7	88.	247	1	85	751	3	83	155	6	100
200	180.8	85	4	176.4	94	2	171.4	102.6	166.2	111.2			200
300	271.2	128.1		264.6	141.3		257.1	153.9	249.3	166.8			300
400	361.6	170.8		352.8	188.4		342.8	205.2	332.4	222.4			400
500	452.0	213.5		441.0	235.5		428.3	256.5	415.5	278.0			500
Dit.	Dep. Lat.		Dep. Lat.		Dep. Lat.		Dep. Lat.		Dep. Lat.		Dep. Lat.		C.M.L Di. Lon
	5 $\frac{1}{4}$ Point.		5 $\frac{1}{2}$ Point.		5 $\frac{3}{4}$ Point.		5 Points.		5 Points.		5 Points.		

A Traverse Table

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Dist.	3 $\frac{1}{2}$ Point		3 $\frac{1}{2}$ Point		3 $\frac{1}{2}$ Point		4 Points		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.	80.	00.	80.	00.	70.	70.	70.	1
2	1.	61.	21.	51.	31.	51.	31.	41.	2
3	2.	41.	32.	31.	42.	22.	02.	12.	3
4	3.	21.	43.	12.	53.	02.	72.	82.	4
5	4.	03.	03.	03.	23.	73.	43.	53.	5
6	4.	83.	64.	63.	84.	44.	04.	24.	6
7	5.	64.	25.	44.	44.	24.	74.	94.	7
8	6.	44.	86.	25.	15.	95.	45.	75.	8
9	7.	25.	47.	02.	76.	75.	06.	46.	9
10	8.	06.	07.	76.	37.	46.	77.	17.	10
15	12.	08.	911.	69.	511.	110.	110.	610.	15
20	16.	111.	915.	512.	714.	813.	414.	114.	20
25	20.	114.	919.	315.	918.	516.	817.	717.	25
30	24.	117.	923.	219.	022.	220.	121.	221.	30
35	28.	120.	827.	022.	325.	923.	324.	724.	35
40	32.	123.	830.	925.	429.	626.	928.	328.	40
45	36.	126.	834.	828.	533.	330.	231.	831.	45
50	40.	229.	838.	631.	737.	033.	635.	335.	50
55	44.	232.	842.	534.	940.	736.	938.	938.	55
60	48.	335.	746.	438.	144.	340.	342.	442.	60
70	56.	241.	754.	144.	451.	947.	049.	549.	70
80	64.	347.	761.	851.	759.	353.	756.	656.	80
90	72.	353.	669.	657.	166.	760.	463.	663.	90
100	80.	359.	677.	363.	474.	167.	270.	770.	100
200	160.6	119.2	154.6	126.8	148.2	134.4	141.4	141.4	200
300	240.9	178.8	231.9	190.2	222.3	201.6	212.1	212.1	300
400	321.2	238.4	309.1	253.6	296.4	268.8	282.8	232.8	400
500	401.5	298.0	386.5	317.0	370.5	336.0	353.5	353.5	500
Dist.	4 $\frac{1}{2}$ Point		4 $\frac{1}{2}$ Point		4 $\frac{1}{2}$ Point		4 Points		C.M.L.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
4 $\frac{1}{2}$ Point			4 $\frac{1}{2}$ Point		4 $\frac{1}{2}$ Point		4 Points		

Dist.	1 Degree		2 Degree		3 Degrees		4 Degrees		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	00	01	00	00	1	00	01	00	1
2	00	02	00	00	12	00	12	00	2
3	00	13	00	00	13	00	23	00	3
4	00	14	00	00	14	00	24	00	4
5	00	15	00	00	25	00	35	00	5
6	00	16	00	00	26	00	46	00	6
7	00	17	00	00	27	00	57	00	7
8	00	18	00	00	28	00	68	00	8
9	00	29	00	00	39	00	69	00	9
10	00	210	00	00	410	00	710	00	10
15	00	315	00	00	515	00	815	01	15
20	00	420	00	00	720	01	019	91	4
25	00	425	00	00	925	01	324	91	7
30	00	530	01	130	01	629	92	1	30
35	00	635	01	434	91	834	92	4	35
40	00	740	01	239	92	139	92	4	40
45	00	845	01	644	92	444	93	1	45
50	00	950	01	849	92	649	93	5	50
55	01	055	01	954	92	954	93	8	55
60	01	060	02	159	93	159	84	2	60
70	01	269	92	469	92	759	85	9	70
80	01	479	92	879	94	279	85	6	80
90	01	689	93	189	94	789	86	3	90
100	01	799	93	599	95	299	87	0	100
200	03	4199	87	0199	810	4199	614	0	200
300	05	1299	710	4299	715	6299	421	0	300
400	06	8399	614	0399	620	8399	228	0	400
500	08	5199	517	5499	525	0499	035	0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif Lon.
	89 Degrees		88 Degrees		87 Degrees		86 Degrees		C.M.L.

Dif.	5 Degrees.		6 Degrees		7 Degrees.		8 Degrees.		C.M.L.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif.	Lon.
11	00	10	10	10	10	10	11	00	1	1
22	00	20	20	20	20	20	22	00	3	2
33	00	30	30	30	30	30	33	00	4	3
44	00	40	40	40	40	40	44	00	6	4
55	00	50	50	50	50	50	55	00	7	5
66	00	60	60	60	60	60	66	00	8	6
77	00	70	70	70	70	70	77	00	9	7
88	00	80	80	80	80	80	88	00	10	8
99	00	90	90	90	90	90	99	00	11	9
1010	00	99	91	09	91	09	1010	00	12	10
1514	91	314	91	614	91	814	82	1	15	15
2019	91	719	92	119	82	419	82	8	20	20
2524	92	224	92	624	83	024	83	5	25	25
3029	52	629	83	129	83	729	74	2	30	30
3534	93	134	83	734	74	334	74	9	35	35
4039	83	539	84	239	74	939	65	6	40	40
4544	83	944	74	744	75	544	66	3	45	45
5049	84	449	75	249	66	149	57	0	50	50
5554	84	854	75	854	66	754	57	6	55	55
6059	85	259	76	359	57	359	48	3	60	60
7069	76	169	67	369	58	569	39	7	70	70
8079	77	079	68	479	49	879	211	1	80	80
9089	77	989	59	489	311	189	112	5	90	90
10099	68	799	410	499	212	299	013	9	100	100
200199	217	4198	820	8198	424	4198	027	8	200	200
300298	826	1298	231	2297	636	6297	041	7	300	300
400398	434	8397	641	6396	848	8396	055	6	400	400
500498	043	5497	052	0496	061	0495	069	5	500	500
Dif.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon.	
85 Degrees		84 Degrees		83 Degrees		82 Degrees		C. M. L.		

A Traverse Table in Degrees.

Dist.	9 Degrees		10 Degr.		11 Degr.		12 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	00	2	00	2	00	2	00	2	1
2	00	3	00	3	00	4	00	4	2
3	00	5	00	5	00	6	00	6	3
4	00	6	00	6	00	8	00	8	4
5	00	8	00	8	00	9	00	9	5
6	00	9	00	9	00	11	00	11	6
7	00	11	00	11	00	13	00	13	7
8	00	12	00	12	00	15	00	15	8
9	00	14	00	14	00	16	00	16	9
10	00	16	00	16	00	18	00	18	10
15	00	24	00	24	00	27	00	27	15
20	00	32	00	32	00	36	00	36	20
25	00	40	00	40	00	45	00	45	25
30	00	48	00	48	00	54	00	54	30
35	00	56	00	56	00	63	00	63	35
40	00	64	00	64	00	72	00	72	40
45	00	72	00	72	00	81	00	81	45
50	00	80	00	80	00	90	00	90	50
55	00	88	00	88	00	99	00	99	55
60	00	96	00	96	00	108	00	108	60
65	00	104	00	104	00	117	00	117	65
70	00	112	00	112	00	126	00	126	70
75	00	120	00	120	00	135	00	135	75
80	00	128	00	128	00	144	00	144	80
85	00	136	00	136	00	153	00	153	85
90	00	144	00	144	00	162	00	162	90
100	00	160	00	160	00	180	00	180	100
200	197.6	31	197.0	34	196.4	38	195.6	41	200
300	296.4	46	295.5	52	294.6	57	293.4	62	300
400	395.2	62	394.0	69	392.8	76	391.2	83	400
500	494.0	78	492.5	87	491.0	95	489.0	104	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon.
	81 Degr.		80 Degr.		79 Degr.		79 Degr.		C.M.L.

A Traverse Table in Degrees.

285

Dif.	13 Degr.		14 Degr.		15 Degr.		16 Degr.		C.M.L.	
	Lar.	Dep.	Lar.	Dep.	Lar.	Dep.	Lar.	Dep.	Dif.	Lon.
1	00	21	00	21	00	31	00	3	1	
2	90	31	90	71	90	51	90	3	2	
3	90	72	90	52	90	82	90	8	3	
4	90	93	91	03	91	93	81	1	4	
5	91	14	81	24	81	34	81	4	5	
6	81	33	81	45	81	55	81	6	6	
7	81	66	81	76	81	86	81	9	7	
8	81	87	81	97	72	17	72	2	8	
9	82	38	72	28	72	38	62	6	9	
10	72	29	72	49	72	69	62	8	10	
15	63	414	53	614	53	913	41	1	15	
20	54	519	44	819	35	219	25	5	20	
25	35	624	36	024	16	524	06	9	25	
30	26	729	17	329	07	828	88	3	30	
35	17	934	08	533	89	033	69	6	35	
40	09	038	89	738	610	338	411	0	40	
45	810	143	711	043	511	643	212	4	45	
50	711	248	512	148	312	948	113	8	50	
55	612	453	413	353	414	252	915	2	55	
60	513	558	214	558	215	557	716	5	60	
70	215	767	916	967	918	167	319	3	70	
80	918	077	619	377	320	776	922	0	80	
90	720	287	321	886	323	386	524	8	90	
100	422	597	024	296	025	996	127	6	100	
200	194.8	45	0194.0	48	4193.0	51	8192.2	55	2	200
300	292.2	67	5291.0	72	6289.0	77	7288.3	82	8	300
400	389.6	90	0388.0	96	8386.0	103.6	284.4	110.5		400
500	487.0	112.5	485.0	121.0	483.0	129.5	480.5	138.0		500
Dif.	Dep.	Lar.	Dep.	Lar.	Dep.	Lar.	Dep.	Lar.	Dif.	Lon.
	77 Degrees	76 Degrees		75 Degr.		74 Degr.		C.M.L.		

Dif.	17 Degr.		18 Degr.		19 Degr.		20 Degr.		C.M.L.
	Lat.	Dep.	Dep.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif. Lon.
1	00	00	30	90	30	90	30	90	3
2	00	00	61	90	61	90	61	90	7
3	00	00	92	90	92	90	92	90	10
4	01	01	23	81	23	81	33	81	4
5	01	01	54	81	54	71	64	71	7
6	01	01	75	71	85	71	95	62	0
7	01	02	06	72	20	62	36	62	4
8	02	02	37	62	57	62	67	52	7
9	02	02	68	62	88	52	98	53	1
10	02	02	99	53	19	53	39	43	4
15	03	03	34	44	64	24	94	15	1
20	03	03	15	819	06	218	96	518	86
25	03	03	97	323	87	723	68	123	58
30	03	03	78	828	59	328	49	828	210
35	03	03	510	233	310	833	111	432	912
40	03	03	211	738	012	437	813	637	613
45	03	03	013	142	813	942	614	642	315
50	03	03	814	647	515	447	316	347	017
55	03	03	616	152	317	052	017	951	718
60	03	03	417	557	118	556	719	556	420
70	03	03	920	566	621	666	222	865	823
80	03	03	523	476	124	775	626	075	227
90	03	03	126	385	627	885	129	384	630
100	03	03	629	229	130	994	532	694	034
200	03	03	191.2	58	4190.2	61	8189.0	65	2188.0
300	03	03	286.8	87	6285.3	92	7283	593	8282.0
400	03	03	382.4	116.8	380.4	123.6	378.0	130.4	376.0
500	03	03	178.2	126.0	475.5	154.5	472.5	163.0	470.0
Dif.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dep.	Dif Lon.
	73 Degr.		72 Degr.		71 Degr.		75 Degr.		C.M.L.

A Traverse Table in Degrees.

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Dist.	21 Degr.		22 Degr.		23 Degr.		24 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
10	90	40	90	40	90	40	90	40	1
21	90	71	80	71	80	71	80	71	2
32	81	12	81	12	81	22	81	22	3
43	71	43	71	53	71	63	61	6	4
54	71	84	61	94	61	94	62	0	5
65	62	15	62	25	52	35	53	4	6
76	52	56	52	66	42	76	42	8	7
87	52	97	43	07	43	17	23	2	8
98	43	28	33	48	63	58	23	7	9
109	33	69	33	79	23	99	14	1	10
1514	05	413	95	613	85	913	76	1	15
2018	77	218	57	518	47	818	38	1	20
2523	39	023	29	423	09	822	8	10	25
3028	016	727	811	227	611	727	412	1	30
3532	712	532	413	132	213	732	014	2	35
4037	314	337	115	036	815	636	516	3	40
4542	016	141	716	841	417	641	118	3	45
5046	717	946	418	746	019	545	720	3	50
5551	319	751	020	650	621	550	222	4	55
6056	021	555	622	555	223	454	824	4	60
7065	325	164	926	264	427	363	528	5	70
8074	728	774	230	073	631	373	132	5	80
9084	032	583	433	782	835	282	236	6	90
10093	435	892	737	592	039	191	440	7	100
200186.8	71	6185.4	75	0184.0	78	2182.8	81	4	200
300280.2	107	4278.1	112	5276.0	117	3274.2	122	1	300
400373.6	143	2370.8	150	0368.0	156	4365.0	162	8	400
500467.0	179	0363.5	187	5460.0	195	5457.0	203	5	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon.
69 Degr.	68 Degr.	65 Degr.	66 Degr.	C.M.L.					

Dist.	25 Degr.		29 Degr.		27 Degr.		28 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0	90	40	90	40	90	40	90	5
2	1	80	81	80	91	80	91	80	9
3	2	71	32	71	32	71	42	61	4
4	3	61	73	61	73	61	83	51	9
5	4	52	14	52	24	52	4	42	3
6	5	42	55	42	65	32	75	32	8
7	6	33	06	33	16	23	26	23	3
8	7	23	47	23	57	13	67	13	8
9	8	03	88	13	98	04	17	94	2
10	9	14	29	04	41	94	58	84	7
15	13	66	313	56	613	46	813	27	0
20	18	18	418	08	817	89	117	71	4
25	22	710	622	511	022	311	322	111	7
30	27	212	727	013	126	713	626	514	1
35	31	714	831	515	331	215	930	916	4
40	36	216	935	917	735	618	235	318	8
45	40	819	040	419	140	120	439	721	1
50	45	321	844	921	944	522	744	123	5
55	49	823	249	424	149	025	048	625	8
60	54	425	453	926	353	527	253	028	2
70	63	429	662	930	762	431	862	832	2
80	72	533	871	935	171	336	370	637	6
90	81	638	080	939	480	240	979	542	2
100	90	642	389	943	889	145	288	346	9
200	181.2	84	6179.8	87	6178.2	90	8176.6	43	8
300	271.8	126	9269.7	131	4267.3	136	2264.9	140	7
400	362.4	169	2359.6	175	2356.2	181	6353.2	187	6
500	453.05	211	0449.5	219	0445.5	227	0441.5	334	5
Dist.	65 Degr.		64 Degr.		63 Degr.		26 Degr.		C.M.L.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon.

Dist.	29 Degr.		30 Degr.		31 Degr.		32 Degr.		C.M.L.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Di.	Lon.
1	0	90	0	90	0	90	0	80	5	1
2	1	71	0	71	0	71	0	71	1	2
3	2	61	42	61	52	61	52	51	6	3
4	3	51	93	52	03	42	13	42	1	4
5	4	42	44	32	54	32	64	22	6	5
6	5	32	95	23	05	13	15	13	2	6
7	6	23	46	13	56	13	5	98	7	7
8	7	13	96	04	06	04	16	84	2	8
9	7	94	47	84	57	74	67	64	8	9
10	8	74	88	75	68	65	18	55	3	10
15	13	17	313	07	512	97	712	77	9	15
20	17	59	717	310	017	110	317	010	6	20
25	21	912	121	612	521	412	921	213	2	25
30	26	214	526	015	025	715	425	415	9	30
35	30	617	030	317	530	018	029	718	5	35
40	35	019	434	620	h34	320	633	921	2	40
45	39	321	839	022	538	623	238	123	8	45
50	43	724	243	325	042	925	742	426	5	50
55	48	126	747	627	547	128	346	629	1	55
60	52	529	152	030	051	430	950	951	8	60
70	61	233	960	635	060	036	059	437	1	70
80	70	038	869	340	068	641	267	842	4	80
90	78	743	677	945	077	146	376	347	7	90
100	87	548	586	650	085	751	584	853	0	100
200	175	097	0173.2	100.0	0171.4	103.6	169	6106	0	200
300	262	5145.5	259.8	150.0	257.1	154.5	254.4	159.1		300
400	350	0194.0	346.4	200.0	342.8	206.0	339.2	212.0		400
500	437	5242.5	435.0	250.0	427.5	257.5	424.0	265.0		500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Di.	Lon.
	61 Degr.		60 Degr.		59 Degr.		58 Degr.		C.M.L.	

Y
X

A
A

Dist.	33 Degr.		34 Degrees		35 Degrees		36 Degrees		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
10	80	50	80	60	80	60	80	60	1
20	71	11	71	11	61	11	61	2	2
30	51	62	51	72	51	72	41	8	3
40	42	23	32	23	32	33	22	3	4
50	22	74	22	84	12	94	02	9	5
60	03	35	03	44	93	44	83	5	6
70	93	85	83	55	74	05	74	1	7
80	74	46	64	56	54	66	54	7	8
90	54	97	55	07	45	27	35	3	9
100	45	48	35	68	25	78	15	9	10
150	08	212	48	412	38	612	18	8	15
200	16	810	916	216	411	516	211	8	20
250	21	013	620	714	020	514	320	114	25
300	25	216	324	916	824	617	224	317	30
350	29	419	129	019	628	720	128	320	35
400	33	621	833	222	432	822	932	423	40
450	37	724	537	323	236	923	836	426	45
500	41	927	241	428	041	028	740	429	50
550	46	130	045	630	745	131	544	532	55
600	50	332	749	733	549	134	448	535	60
700	58	738	158	039	157	340	156	641	70
800	67	143	666	344	765	545	964	747	80
900	75	549	074	650	372	751	672	852	90
1000	83	954	582	955	981	957	480	958	100
200	167	8109.0	165.8	111.8	163.8	114.8	161.8	117.6	200
300	251	7163.5	248.7	167.7	245.7	172.2	242.7	176.4	300
400	335	6218.0	331.6	223.6	327.6	229.6	323.6	235.2	400
500	419	5272.5	414.5	279.5	409.5	287.0	404.5	284.0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Di. Lon
57 Degrees			56 Degrees		55 Degrees		54 Degrees		C.M.L.

29F

Dist.	37 Degr.		38 Degr.		39 Degr.		40 Degr.		C.M.L.
	Lar.	Dep.	Lar.	Dep.	Lar.	Dep.	Lar.	Dep.	Di. Lon
1	0.	80	60	80	60	80	70	80	6
2	1.	61	21	61	21	51	31	51	3
3	2.	41	82	41	82	31	92	31	9
4	3.	22	43	12	53	52	53	12	6
5	4.	03	03	93	13	93	13	83	2
6	4.	83	64	73	74	63	94	63	9
7	5.	64	25	54	35	44	45	44	5
8	6.	44	86	34	56	25	06	15	1
9	7.	25	47	15	57	05	76	95	8
10	8.	06	07	96	27	86	37	76	4
15	12.	09	011	89	311	69	411	59	6
20	16.	012	015	812	315	512	015	312	9
25	20.	015	019	715	419	415	919	116	1
30	24.	018	023	618	523	318	923	019	3
35	27.	921	127	621	527	222	026	822	5
40	31.	924	131	524	631	125	230	625	7
45	35.	927	135	527	735	028	334	528	9
50	39.	930	139	430	838	931	538	332	1
55	43.	933	143	333	942	734	642	135	4
60	47.	936	147	336	946	637	846	038	6
70	55.	942	155	243	154	444	053	645	0
80	63.	948	163	049	362	250	361	351	4
90	71.	954	270	955	469	956	668	957	4
100	79.	960	278	861	677	762	976	664	3
200	159.8	120.4	157.6	123.2	155.4	125.8	153.2	128.6	200
300	239.7	180.6	236.4	184.8	232.1	188.7	229.8	192.9	300
400	319.6	240.8	315.2	246.4	310.8	251.6	306.4	257.2	400
500	399.5	301.0	394.0	308.0	388.5	314.5	383.0	321.5	500
Dist.	Dep. Lar.		Dep. Lar.		Dep. Lar.		Dep. Lar.		Di. Lon
	52 Degr.		52 Degr.		51 Degr.		50 Degr.		C.M.L.

Dist.	41 Degr.		42 Degr.		43 Degr.		44 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
10	70	70	70	70	70	70	70	70	1
21	51	31	51	31	51	31	41	41	2
32	32	02	22	02	22	02	22	1	3
43	02	63	02	72	92	72	92	8	4
53	83	33	73	33	63	43	63	5	5
64	53	94	54	04	44	14	34	2	6
75	34	65	24	75	14	85	04	9	7
86	05	25	95	35	85	55	75	6	8
96	85	96	76	06	66	16	56	2	9
107	56	67	46	77	36	87	26	9	10
118	39	11	210	011	010	210	810	4	15
2015	113	314	913	414	613	614	413	2	20
2518	916	418	616	713	317	118	017	4	25
3622	619	722	320	121	920	521	620	8	30
3526	423	026	023	425	623	925	224	3	35
4030	226	229	726	829	227	328	827	8	40
4534	029	533	430	132	930	732	431	3	45
5037	732	837	233	536	634	136	034	7	50
5541	536	1040	936	840	237	539	638	2	55
6045	339	444	649	143	840	943	241	7	60
7052	845	954	046	851	247	750	348	6	70
8060	452	559	453	558	554	657	555	6	80
9067	959	060	960	265	861	464	762	5	90
10075	565	674	366	973	168	274	969	5	100
200151	0131.2	148.6	133.8	146.2	136.4	143.8	139.0		200
300226.5	196.8	222.9	200.7	219.3	204.6	215.7	208.5		300
400302.0	262.4	297.2	267.6	292.4	272.8	287.6	278.0		400
500377.3	328.0	371.5	334.5	365.5	341.0	359.5	347.5		500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Di Lon
	49 Degrees		48 Degrees		47 Degrees		46 Degrees		C.M.L.

N^o. 11. A Table shewing the Dist. Run, Diff. Lat. or Dep. for every Point, Half, or Quarter Point of the Compass.

Angle of the Course in Degrees and Decimals.	Distance.	Diff. Lat. or Departure	N ^o . 12. A Table shewing the Reduction of Minutes into Decimals, and the contrary.			
			M	Decims.	M	Decims.
2.8125	20.39	20.37	1	.0167	15	.2500
5.625	10.21	10.15	2	.0333	16	.2667
8.4375	6.82	6.74	3	.0500	17	.2833
11.25	5.13	5.03	4	.0667	18	.3000
14.0625	4.14	3.87	5	.0833	19	.3167
16.875	3.41	3.37	6	.1000	20	.3333
19.6875	2.97	2.797	7	.1167	21	.3500
22.5	2.614	2.416	8	.1333	22	.3667
25.3125	2.340	2.115	9	.1500	23	.3833
28.125	2.122	1.871	10	.1667	24	.4000
30.9375	1.945	1.669	11	.1833	25	.4167
33.75	1.800	1.496	12	.2000	26	.4333
36.5625	1.678	1.348	13	.2167	27	.4500
39.375	1.576	1.218	14	.2333	18	.4677
42.1875	1.462	1.153				
45.	1.000	1.000				

The Table of Decimals continu'd.

M	Decims.	M	Decims.	M	Decims.	M	Decims.
29	.4833	37	.6167	45	.7500	53	.8833
30	.5000	38	.6333	46	.7667	54	.9000
31	.5167	39	.6500	47	.7833	55	.9167
32	.7333	40	.6667	48	.8000	56	.9333
33	.5500	41	.6833	49	.8167	57	.9500
34	.5667	42	.7700	50	.8333	58	.9767
35	.5833	43	.7167	51	.8500	59	.9833
36	.6000	44	.7333	52	.8667	60	.10000

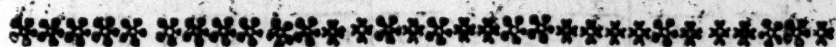
<u>Deg.</u>	<u>Sec.</u>	<u>Deg.</u>	<u>Sec.</u>	<u>Deg.</u>	<u>Secant</u>
0	1000	31	1167	62	2130
1	1000	32	1179	63	2203
2	1001	33	1192	64	2281
3	1001	34	1206	65	2366
4	1002	35	1221	66	2458
5	1004	36	1236	67	2559
6	1005	37	1252	68	2669
7	1007	38	1269	69	2790
8	1010	39	1287	70	2924
9	1015	40	1305	71	3071
10	1019	41	1325	72	3236
11	1022	42	1346	73	3420
12	1026	43	1367	74	3628
13	1026	44	1390	75	3864
14	1031	45	1414	76	4133
15	1035	46	1439	77	4445
16	1040	47	1466	78	4810
17	1046	48	1494	79	5241
18	1051	49	1524	80	5759
19	1058	50	1556	81	6392
20	1064	51	1589	82	7285
21	1071	52	1624	83	8205
22	1078	53	1662	84	9567
23	1086	54	1701	85	11474
24	1095	55	1743	86	14335
25	1103	56	1788	87	19107
26	1113	57	1836	88	28654
27	1122	58	1887	89	57299
28	1132	59	1942	90	<i>Infini</i>
29	1143	60	2000		
30	1155	61	2063		



A
T A B L E
O F

Meridional Parts,

For the Making or Exact Construction
of the Meridian Line in a Mercator's
Chart; and Solving the Cases in
Mercator's Sailing.



Deg. of Lat.	The Minutes of each Degree.						Difference.
	0 m.	5 m.	10 m.	15 m.	20 m.	25 m.	
	The Meridional Parts.						
0	0	5	10	15	20	25	5
1	60	65	70	75	80	85	5
2	120	125	130	135	140	145	5
3	180	185	190	195	200	205	5
4	240	245	250	255	260	265	5
5	300	305	310	315	320	325	5
6	361	366	371	376	381	386	5
7	421	426	431	436	441	446	5
8	482	487	492	497	502	507	5
9	542	547	552	557	562	567	5
10	603	608	613	618	623	628	5
11	664	669	674	679	684	690	5
12	725	730	736	741	746	751	5
13	787	792	797	802	807	812	5
14	845	854	859	864	869	874	5
15	910	916	921	926	931	936	5
16	973	978	983	988	994	999	5
17	1035	1041	1046	1051	1056	1061	6
18	1098	1103	1109	1114	1119	1125	6
19	1161	1167	1172	1177	1183	1188	6
20	1225	1230	1236	1241	1246	1252	6
21	1289	1295	1300	1305	1311	1316	6
22	1354	1359	1364	1370	1375	1381	6
23	1419	1424	1429	1435	1440	1446	6
24	1484	1490	1495	1500	1506	1511	6
25	1550	1556	1561	1567	1572	1578	6
26	1616	1622	1628	1633	1639	1644	6
27	1684	1689	1695	1700	1706	1712	6
28	1751	1757	1762	1768	1774	1780	6
29	1819	1825	1831	1837	1842	1848	6

Deg. of Lat.	The Minutes of each Degree.						Difference.
	30m.	35 m.	40m.	45 m.	50m	55 m	
	The Meridional Parts.						
0	30	35	40	45	50	55	5
1	90	95	100	105	110	115	5
2	150	155	160	165	170	175	5
3	210	215	220	225	230	235	5
4	270	275	280	285	290	295	5
5	330	335	341	346	351	356	5
6	391	396	401	406	411	416	5
7	451	456	461	466	471	476	5
8	512	517	522	527	532	537	5
9	573	578	583	588	593	598	5
10	634	639	644	649	654	659	5
11	695	700	705	710	715	720	5
12	756	761	766	771	776	781	5
13	818	823	828	833	838	843	5
14	879	885	890	895	900	905	5
15	942	947	952	957	962	967	5
16	1004	1009	1014	1020	1025	1030	5
17	1067	1072	1077	1082	1088	1093	6
18	1130	1135	1140	1146	1151	1156	6
19	1193	1199	1204	1209	1214	1220	6
20	1257	1262	1268	1273	1278	1284	6
21	1321	1327	1332	1338	1343	1348	6
22	1386	1392	1397	1402	1408	1413	6
23	1451	1457	1462	1468	1473	1479	6
24	1517	1522	1528	1533	1539	1544	6
25	1583	1589	1594	1600	1605	1611	6
26	1650	1656	1661	1667	1672	1678	6
27	1717	1723	1729	1734	1740	1745	6
28	1785	1791	1797	1802	1808	1814	6
29	1854	1860	1865	1871	1877	1883	6

Deg. of Lat.	The Minutes of each Degree.						Difference.
	0 m	5 m.	10 m.	15 m.	20 m.	25 m	
	The Meridional Parts.						
30	1888	1894	1900	1906	1912	1917	6
31	1958	1964	1970	1976	1981	9987	6
32	2028	2034	2040	2046	2052	2058	6
33	2100	2106	2111	2117	2123	2129	6
34	2171	2177	2183	2190	2196	2202	6
35	2244	2250	2256	2263	2269	2275	6
36	2318	2324	2330	2336	2343	2349	6
37	2393	2399	2405	2411	2418	2424	6
38	2468	2475	2481	2487	2494	2500	7
39	2544	2551	2558	2564	2571	2577	7
40	2622	2629	2636	2642	2649	2655	7
41	2702	2708	2715	2722	2728	2735	7
42	2782	2789	2795	2802	2809	2816	7
43	2863	2870	2877	2884	2891	2897	7
44	2946	2953	2960	2967	2974	2981	7
45	3030	3037	3044	3051	3058	3066	7
46	3116	3123	3130	3137	3145	3152	7
47	3203	3210	3217	3225	3232	3240	8
48	3292	3299	3307	3314	3322	3329	8
49	3382	3390	3397	3405	3413	3420	8
50	3475	3482	3490	3498	3506	3514	8
51	3569	3577	3585	3593	3601	3609	8
52	3665	3673	3682	3690	3698	3706	8
53	3764	3772	3781	3789	3797	3808	8
54	3855	3873	3882	3890	3899	3908	9
55	3968	3977	3986	3994	4003	4012	9
56	4074	4083	4092	4101	4110	4119	9
57	4183	4192	4201	4211	4220	4229	9
58	4295	4304	4314	4323	4333	4342	10
59	4409	4410	4429	4439	4448	4458	10

Deg. of Lat.	The Minutes of each Degree.						Difference.
	30 m	35 m	40 m.	45 m.	50 m	55 m	
	The Meridional Parts.						
30	1923	1929	1935	1941	1946	1952	6
31	1993	1999	2005	2011	2017	2022	6
32	2064	2070	2076	2082	2088	2094	6
33	2135	2141	2147	2153	2159	2165	6
34	2208	2214	2220	2226	2232	2238	6
35	2281	2287	2293	2300	2306	2312	6
36	2355	2361	2368	2374	2380	2386	6
37	2430	2437	2443	2449	2456	2462	6
38	2507	2513	2519	2526	2532	2539	7
39	2584	2590	2597	2603	2610	2616	7
40	2662	2669	2675	2682	2688	2695	7
41	2742	2748	2755	2762	2768	2775	7
42	2822	2829	2836	2843	2850	2856	7
43	2904	2911	2918	2925	2932	2939	7
44	2988	2995	3002	3009	3016	3023	7
45	3073	3080	3087	3094	3101	3108	7
46	3159	3166	3174	3181	3188	3195	7
47	3247	3254	3262	3269	3277	3284	8
48	3337	3344	3352	3359	3367	3374	8
49	3428	3436	3444	3451	3459	3467	8
50	3522	3529	3537	3545	3553	3561	8
51	3617	3625	3633	3641	3649	3657	8
52	3714	3723	3731	3739	3747	3756	8
53	3814	3823	3831	3839	3848	3856	9
54	3916	3925	3933	3942	3951	3989	9
55	4021	4030	4039	4047	4056	4065	9
56	4128	4137	4146	4155	4165	4174	9
57	4238	4248	4256	4266	4276	4285	9
58	4352	4361	4371	4380	4390	4400	10
59	4468	4478	4488	4498	4508	4518	10

A Table of Meridional Parts.

Deg. of Lat.	The Minutes of each Degree.						Difference.
	0 m.	5 m.	10 m.	15 m.	20 m.	25 m.	
	The Meridional Parts.						
60	4528	4538	4548	4558	4568	4578	10
61	4649	4660	4670	4681	4691	4702	11
62	4775	4786	4797	4807	4818	4829	11
63	4905	4916	4927	4938	4949	4960	11
64	5040	5051	5062	5074	5086	5099	12
65	5179	5191	5203	5215	5227	5237	12
66	5324	5336	5349	5361	5374	5386	13
67	5475	5487	5500	5513	5526	5539	13
68	5631	5643	5658	5672	5685	5699	14
69	5795	5809	5823	5837	5851	5865	14
70	5967	5981	5996	6011	6026	6041	15
71	6146	6162	6177	6193	6209	6225	16
72	6336	6352	6368	6384	6401	6417	16
73	6535	6552	6570	6587	6603	6622	17
74	6747	6765	6783	6801	6819	6839	18
75	6971	6991	7010	7030	7050	7070	20
76	7211	7232	7253	7274	7295	7316	21
77	7469	7491	7513	7536	7559	7582	23
78	7746	7770	7794	7819	7844	7869	25
79	8048	8074	8100	8127	8154	8181	27
80	8376	8406	8431	8465	8495	8525	30
81	8741	8774	8806	8839	8872	8905	33
82	9148	9184	9221	9258	9295	9333	37
83	9609	9650	9692	9735	9821	9821	42
84	10148	10188	10237	10287	10338	10389	50

Deg. of Lat.	The Minutes of each Degree.						Difference.
	30 m.	35 m.	40 m.	45 m.	50 m.	55 m.	
	The Meridional Parts.						
60	4508	4598	4609	4619	4629	4639	10
61	4712	4722	4733	4744	4754	4665	11
62	4840	4851	4862	4872	4883	4894	11
63	4972	4983	4995	5006	5017	5028	11
64	5100	5121	5132	5144	5156	5167	12
65	5251	5263	5275	5287	5309	5312	12
66	5399	5411	5424	5436	5449	5462	13
67	5552	5565	5578	5592	5605	5618	13
68	5712	5726	5739	5753	5767	5781	14
69	5880	5894	5909	5923	5938	5953	15
70	6056	6071	6086	6101	6116	6131	15
71	6240	6256	6272	6288	6304	6320	16
72	6434	6451	6468	6484	6501	6518	17
73	6640	6657	6675	6693	6711	6729	18
74	6857	6876	6895	6914	6933	6952	19
75	7090	7110	7130	7150	7170	7190	20
76	7337	7359	7381	7403	7425	7447	22
77	7605	7628	7651	7675	7698	7722	24
78	7894	7919	7944	7970	7996	8022	26
79	8208	8236	8264	8292	8320	8349	28
80	8555	8586	8617	8648	8679	8710	31
81	8939	8973	9007	9042	9077	9113	35
82	9371	9410	9449	9488	9528	9568	40
83	9864	9910	9953	10000	10046	10093	46
84	10441	10494	10547	10601	10656	10713	55

A Table of Proportional Parts.

D.	1	2	3	4	D.	1	2	3	4
5	1	2	3	4	22	4	9	13	18
6	1	2	3	5	23	5	9	14	18
7	1	3	4	6	24	5	10	14	19
8	2	3	5	6	25	5	10	15	20
9	2	4	5	7	26	5	10	16	21
10	2	4	6	8	27	5	11	16	22
11	2	4	7	9	28	6	11	17	22
12	2	5	7	10	30	6	12	18	24
13	3	5	8	10	31	6	12	19	25
14	3	6	8	11	33	7	13	20	26
15	3	6	9	12	35	7	14	21	28
16	3	6	10	13	37	7	15	22	30
17	3	7	10	14	40	8	16	24	32
18	4	7	11	14	42	8	17	25	34
19	4	8	12	15	46	9	18	29	37
20	4	8	13	16	50	10	20	30	40
21	4	8	13	17	55	11	22	33	44

TABLE 14.

Lat.	Miles.	Lat.	Miles.
D.M.	Long.	D.M.	Long.
18.11	57	63.15	27
25.50	54	66.25	24
31.47	51	69.31	21
36.52	48	72.32	18
41.25	45	75.31	15
45.34	42	78.28	12
49.27	39	81.22	9
53.08	36	84.16	6
56.38	33	87.08	3
60.00	30		

A Table shewing how many Miles do answer to a Degree of Longitude at every Degree of Latitude.

D.I	Miles.	D.I	Miles.	D.I	Miles.	D.I	Miles.	N ^o . 16.		
								P.	Dist.	Dep.
1	59.99	23	55.23	45	42.43	67	23.45	1	60.1	3.0
2	59.96	24	54.81	46	41.68	68	22.48	2	60.3	6.0
3	59.92	25	54.38	47	40.92	69	21.50	3	60.6	8.8
4	59.86	26	53.93	48	40.15	70	20.52	I.	61.1	12.1
5	59.77	27	53.46	49	39.36	71	19.54	1	61.9	15.0
6	59.67	28	52.97	50	38.57	72	18.55	2	62.7	18.2
7	59.56	29	52.47	51	37.76	73	17.54	3	63.7	22.5
8	59.42	30	51.96	52	36.94	74	16.53	II.	64.9	24.8
6	59.26	31	51.43	53	36.11	75	15.52	1	66.4	28.4
10	59.08	32	50.88	54	35.26	76	14.51	2	68.0	32.1
11	58.89	33	50.32	55	34.41	77	13.50	3	70.0	36.1
12	58.68	34	49.74	56	33.55	78	12.48	III.	72.2	40.1
13	58.46	35	49.15	57	32.68	79	11.45	1	74.7	44.5
14	58.22	36	48.54	58	31.79	80	10.42	2	77.7	49.3
15	57.95	37	47.92	59	30.90	81	9.38	3	81.6	54.4
16	57.67	38	47.28	60	30.00	82	8.35	IV.	84.9	60.0
17	57.37	39	46.62	61	29.09	83	7.32	1	89.4	66.2
18	57.06	40	45.95	62	28.17	84	6.28	2	94.6	73.2
19	56.73	41	45.28	63	27.24	85	5.23	3	106.6	81.0
20	56.38	42	44.59	64	26.30	86	4.18	V.	108.0	89.8
21	56.01	43	43.88	65	25.36	87	3.14	1	120.0	100.2
22	55.63	44	43.16	66	24.41	88	2.09	2	127.0	113.0
23	55.23	45	42.43	67	23.45	89	1.05	3	140.0	127.0
Diff-rence Lat. on all Rhumbs 60								VI.	157.0	144.0
								1	178.0	168.1
								2	207.8	198.0
								3	247.0	240.2
								VII	308.0	303.0
								1	409.0	405.0
								2	613.0	610.0
								3	1221.0	1220.0
								VIII.	Infinite.	

The Names of the Pieces of Ordnance.	Guns Weight	Diameter of the Bore.	Diameter of the Shot.	Weight of the Shot.	Powder for Proof.	Powder for Service.	Paces Point- Blank.	Utmost Random.
	Lb.	I. P.	I. P.	lb. oz.	lb. oz.	lb. oz.	Paces.	Paces.
Cannon Royal	8000	8 07	4 58	0 27 0	23 0	180	1800	
Cannon 7.	6000	6 66	5 42	0 24 0	18 0	180	1800	
Demi-Cannon	3200	6 96	7 22	0 20 0	15 0	180	1800	
24 Pounders.	4800	5 65	6 24	0 17 0	11 0	180	1810	
Culverin large	4500	5 35	1 18	0 14 0	10 0	184	1840	
12 Pounders.	3000	4 44	2 10	0 10 5	8 0	178	1780	
Demi-Culver.	2700	4 24	0 9 0	9 0 7	0	175	1750	
Saker.	1500	3 53	4 7	4 5 4	0	160	1600	
Minion.	1000	3 23	0 3 12	3 12 3	0	120	1200	
Faucons.	750	2 62	4 2 8	2 5 1	8	120	1200	
Rabanet.	300	1 4 18	2 0 8	0 18 0	12	120	1200	
Bale.	200	1 2 18	0 0 5	0 15 0	8	107	1070	

Note, The Paces are accounted Five Foot each : Point-Blank is upon the Level : The Utmost Random, is when the Piece is mounted to Forty five Degrees. The rest of the *Table* is obvious, and was inserted here, to supply a Vacancy of this Page, and may be of good Use to the Sea-Gunner, &c.

Astronomical TABLES.

1. A Table of the Sun's Declination.
2. A Table of the Refractions of the Sun, Moon and Stars.
3. A Table of the Sun's Rising and Setting, from the Equinoctial to 60 Degrees of Latitude North or South.
4. A Table shewing the Longest Day in any Latitude.
5. A Table of the Sun's Amplitudes East or West, from the Equinoctial to 60 Degrees of Latitude, North or South.
6. A Table of the Sun's Right Ascension in Time throughout the Year.
7. A Table of the Semi-Diurnal Arks, Seasons for Observing, Right Ascension and Declination of some Principal Fixed Stars.

First Year after Leap-Year.
 Sun's Declination 1733. 1737. 1741. 1745. 1749.

Days	Jan.		Febr.		Mar.		April.		May.		June.	
	South.		South.		South.		North.		North.		North.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	VS 39	13	39	2	X 17	8	V 43	18	O 09	23	II 11
2	21	28	13	19	2	58	9	5	18	24	23	15
3	21	18	12	59	2	29	9	26	18	39	23	18
4	21	07	12	38	2	05	9	47	18	53	23	21
5	20	56	12	17	1	42	10	00	19	07	23	23
6	20	44	11	56	1	18	10	30	19	21	23	25
7	20	32	11	35	0	54	10	51	19	34	23	27
8	20	19	11	14	0	31	11	12	19	47	23	28
9	20	16	10	X 53	0	07	11	O 32	20	00	23	29
					North							
10	19	53	10	31	0	V 16	11	53	20	12	23	29
11	19	38	10	9	0	40	12	13	20	II 25	23	O 29
12	19	25	9	47	1	04	12	53	20	36	23	29
13	19	11	9	25	1	27	12	53	20	48	23	28
14	18	56	9	03	1	51	13	13	20	59	23	27
15	18	41	8	40	1	14	13	32	21	09	23	25
16	18	26	8	18	2	38	13	51	21	19	23	23
17	18	10	7	55	3	01	14	10	21	29	23	20
18	17	54	7	32	3	25	14	29	21	39	23	17
19	17	38	7	10	3	48	14	47	21	48	23	14
20	17	21	6	47	4	11	15	06	21	57	23	10
21	17	04	6	24	4	34	15	24	22	05	23	06
22	16	47	6	01	4	57	15	42	22	13	23	01
23	16	29	5	37	5	20	15	59	22	21	22	56
24	16	12	5	14	5	43	16	16	22	28	22	51
25	15	53	4	51	6	6	16	33	22	35	22	45
26	15	35	4	27	6	29	16	50	22	41	22	39
27	15	16	4	04	6	51	17	06	22	47	22	32
28	14	57	3	40	7	14	17	23	22	53	22	25
29	14	31			7	36	17	38	22	58	22	18
30	14	19			7	58	17	54	23	03	22	10
31	13	59			8	21			23	07		

A Table of the Sun's Declination.

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First Year after Leap-Year.
Sun's Declination 1733. 1737. 1741. 1745. 1749.

Dys.	July.	August.	Sept.	Octob.	Nov.	Dec.
	North.	North.	North.	South.	South.	South.
	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.
1	22 50	15 02	4 12	7 25	17 46	23 08
2	21 53	14 44	3 49	7 48	18 02	22 12
3	21 44	14 25	3 26	8 10	18 18	23 16
4	21 35	13 07	3 03	8 33	18 33	23 20
5	21 25	13 48	2 40	8 55	18 48	23 22
6	21 15	13 29	2 16	9 17	19 03	23 24
7	21 05	13 09	1 55	9 39	19 18	24 26
8	20 54	12 50	1 30	10 01	19 32	23 28
9	20 43	12 30	1 06	10 23	19 46	23 29
10	20 43	12 10	0 43	10 44	19 59	23 29
11	20 20	11 50	0 19	11 06	20 12	23 29
12	20 08	11 50	0 04	11 27	20 25	23 22
13	19 56	11 10	Sou 27	11 48	20 37	23 27
14	19 44	10 48	0 51	12 09	20 49	23 26
15	19 30	10 28	1 14	12 29	21 01	23 24
16	19 17	10 17	1 38	12 50	21 12	23 22
17	19 04	9 43	2 01	13 10	21 22	23 19
18	18 49	9 24	2 25	13 30	21 33	23 16
19	18 34	9 03	2 48	13 40	21 43	23 12
20	18 20	8 41	3 12	14 10	21 52	23 08
21	18 05	8 19	3 36	14 29	22 01	23 03
22	17 50	7 57	3 58	14 48	22 10	22 58
23	17 34	7 35	4 22	15 07	22 18	22 52
24	17 18	7 13	4 45	15 26	22 26	22 46
25	17 02	6 51	5 08	15 44	22 34	22 39
26	16 46	6 28	5 31	16 03	22 41	22 32
27	16 29	6 06	5 54	16 20	22 47	22 25
28	16 12	5 43	6 17	16 38	22 53	22 17
29	15 55	5 21	6 40	16 55	22 58	22 09
30	15 38	4 58	7 03	17 13	23 03	22 00
31	15 20	3 35		17 29		21 51

A Table of the Sun's Declination.

Second Year after Leap-Year,
 Sun's Declination 1734, 1738, 1742, 1746, 1750.

Days.	Jan.		Febr.		Mar.		April.		May.		June.	
	South.		South.		South.		North.		North.		North.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	41	13	44	3	22	8	37	18	06	23	10
2	21	31	13	24	2	39	8	39	18	21	23	14
3	21	21	13	04	2	35	9	21	18	35	23	17
4	21	10	12	45	2	11	9	42	18	50	23	20
5	20	50	12	22	1	48	10	03	19	04	23	23
6	20	47	12	01	1	24	10	25	19	18	23	25
7	20	35	11	40	1	00	10	46	19	51	23	29
8	20	22	11	19	0	57	11	07	19	44	23	28
9	20	10	10	58	0	13	11	27	19	37	23	29
10	19	59	10	36	North		11	48	20	10	23	29
11	19	45	10	14	0	34	12	08	00	22	23	29
12	19	29	9	52	0	58	12	28	20	33	23	29
13	19	15	9	32	1	21	12	48	20	45	23	28
14	19	00	9	08	1	45	13	08	20	56	23	27
15	18	45	8	46	2	08	13	27	21	07	23	25
16	18	30	8	23	2	32	13	47	21	17	23	23
17	18	24	8	01	2	55	14	06	21	27	23	21
18	17	58	7	38	3	18	14	24	21	56	22	18
19	17	42	7	15	3	42	14	43	21	45	22	14
20	17	25	6	52	4	05	15	01	21	54	22	11
21	17	08		29	4	29	15	19	22	03	22	07
22	16	51		06	4	52	15	37	22	11	22	02
23	16	34	5	43	5	15	15	55	22	19	22	57
24	16	16	5	20	5	58	16	12	22	26	22	52
25	15	58	4	57	6	01	16	10	22	55	22	46
26	15	39	4	33	6	23	16	46	22	40	22	40
27	15	21	4	09	6	46	17	02	22	46	22	54
28	15	02	3	46	7	08	17	19	22	51	22	27
29	14	43			7	31	17	35	22	57	22	20
30	14	25			7	53	17	50	23	02	22	12
31	14	04			8	15			23	06		

A Table of the Sun's Declination.

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Second Year after Leap-Year.
Sun's Declination 1734. 1738, 1742, 1746, 1750.

Days.	July.		Aug.		Sept.		Octob.		Nov.		Dec.	
	North.		North.		North		South.		South.		South	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	22	04	15	06	4	18	7	20	17	42	23	07
2	21	54	14	48	3	55	7	42	17	58	23	11
3	21	46	14	30	3	32	8	05	18	14	23	15
4	21	37	14	11	3	08	8	27	18	29	23	19
5	21	28	13	52	2	45	1	50	18	45	23	22
6	21	18	13	33	2	22	9	12	18	59	23	24
7	21	08	13	14	1	59	9	34	19	14	23	26
8	20	57	12	54	1	35	9	56	19	28	23	28
9	20	46	12	35	1	12	10	17	19	42	23	28
10	20	35	12	15	0	48	10	4	99	56	23	29
11	20	23	11	55	0	25	11	00	20	09	23	29
12	20	11	11	35	0	02	11	22	20	22	23	29
13	19	59	11	14	Sou	22	11	43	20	34	23	28
14	19	46	10	53	0	45	12	03	20	46	23	27
15	19	33	10	33	1	09	12	24	10	58	23	25
16	19	20	10	12	1	32	12	45	21	09	23	22
17	19	06	9	51	1	56	13	05	21	20	23	19
18	18	51	9	29	2	19	13	25	21	30	23	16
19	18	38	9	08	2	42	13	45	21	40	23	12
20	18	22	8	46	3	06	14	05	21	50	23	09
21	18	08	8	25	3	29	14	24	21	59	23	04
22	17	53	8	03	3	53	14	44	22	08	22	59
23	17	38	7	41	4	16	15	03	22	16	22	53
24	17	22	7	19	4	39	15	21	22	24	22	47
25	17	06	6	56	5	02	15	40	22	32	22	41
26	16	50	6	34	5	25	15	58	22	39	22	34
27	16	33	6	12	5	48	16	16	22	45	22	27
28	16	16	5	49	6	11	16	34	22	52	22	19
29	15	59	5	26	6	34	16	51	22	57	22	11
30	15	42	5	04	6	57	17	08	23	02	22	02
31	15	24	4	41			17	25			21	53

Third

Third Year after Leap-Year.
Sun's Declination 1735, 1739, 1743, 1747, 1751.

Days.	Jan.		Febr.		Mar.		April.		May.		June.	
	South.		South.		North.		North.		North.		North.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	43	13	49	3	28	8	32	18	02	23	09
2	21	33	13	29	3	04	8	54	18	17	23	13
3	21	23	13	09	2	41	9	15	18	32	23	17
4	21	12	12	48	2	17	9	37	18	46	23	20
5	21	01	12	27	1	54	9	58	19	01	23	22
6	20	50	12	06	1	30	10	20	19	14	23	24
7	20	38	11	46	1	06	10	41	19	28	23	26
8	20	25	11	24	0	43	11	02	19	41	23	27
9	20	13	11	03	0	19	11	22	19	54	23	28
10	20	00	10	41	Noros		11	43	20	06	23	29
11	19	46	10	20	0	28	12	03	20	18	23	29
12	19	32	9	58	0	52	12	23	20	30	23	29
13	19	18	9	36	1	16	12	43	20	42	23	28
14	19	04	9	14	1	39	13	03	20	53	23	27
15	18	49	8	51	2	03	13	23	21	04	23	25
16	18	33	8	29	2	26	13	42	21	14	23	23
17	18	18	8	06	2	50	14	01	21	24	23	21
18	18	02	7	44	3	13	14	20	21	34	23	18
19	17	46	7	21	3	36	14	39	21	43	23	15
20	17	29	6	58	4	00	14	57	21	52	23	12
21	17	13	6	35	4	23	15	15	22	01	23	08
22	16	55	6	12	4	46	15	33	22	09	23	03
23	16	38	5	49	5	09	15	51	22	17	22	58
24	16	20	5	25	5	32	16	08	22	24	22	53
25	16	02	5	02	5	55	16	25	22	31	22	48
26	15	44	4	39	6	18	16	42	22	38	22	42
27	15	25	4	15	6	40	16	58	22	44	22	35
28	15	07	3	52	7	03	17	15	22	50	22	28
29	14	48			7	25	17	31	22	55	22	21
30	14	28			7	48	17	46	23	00	22	14
31	14	00			8	10			23	05		

A Table of the Sun's Declination.

311

Third Year after Leap-Year.
Sun's Declination 1735, 1739, 1743, 1747, 1751.

Days.	July.		August.		Sept.		Octob.		Nov.		Dec.	
	North.		North.		North.		South.		South.		South.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	22	05	15	11	4	23	7	14	17	38	23	06
2	21	57	14	53	4	00	7	37	17	54	23	10
3	21	49	14	34	3	57	8	00	18	10	23	14
4	21	40	14	16	3	14	8	22	18	26	23	18
5	21	30	13	57	2	51	8	44	18	41	23	21
6	21	20	13	38	2	28	9	06	18	56	23	23
7	21	10	13	19	2	04	9	28	19	11	23	25
8	21	00	12	59	1	41	9	50	19	25	23	27
9	20	49	12	49	1	18	10	12	19	39	23	28
10	20	38	12	20	0	54	10	34	19	52	23	29
11	20	26	12	00	0	31	10	55	20	06	23	29
12	20	14	11	40	0	07	11	17	20	19	23	29
13	20	02	11	19	South		11	38	20	31	23	28
14	19	49	10	59	0	39	11	59	20	45	23	27
15	19	36	10	38	1	03	12	19	20	55	23	25
16	19	03	10	17	1	26	12	40	21	06	23	23
17	19	09	9	56	1	50	13	00	21	17	23	20
18	18	57	9	35	2	13	13	21	21	28	23	17
19	18	41	9	13	2	37	13	40	21	38	23	14
20	18	27	8	52	3	00	14	00	21	48	23	10
21	18	12	8	30	3	24	14	20	21	57	23	05
22	17	57	8	08	3	47	14	39	22	06	23	00
23	17	42	7	46	4	10	14	58	22	14	22	55
24	17	26	7	24	4	23	15	17	22	22	22	49
25	17	10	7	02	4	57	15	35	22	30	22	43
26	16	54	6	40	5	20	15	54	22	37	22	36
27	16	37	6	17	5	43	16	12	22	44	22	28
28	16	20	5	55	6	06	16	29	22	50	22	21
29	16	05	5	42	6	29	16	41	22	56	22	13
30	15	46	5	09	6	52	17	04	23	10	22	04
31	15	28	4	46			17	41			21	55

Leap-

Leap-Year.

Sun's Declination 1732, 1736, 1740, 1744, 1748.

Days.	Jan.		Febr.		Mar.		April.		May.		June.	
	South.		South.		South.		North.		North.		North.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	46	13	54	3	10	8	48	18	13	23	12
2	21	36	13	34	2	47	9	10	18	28	23	16
3	21	26	13	14	2	23	9	32	18	43	23	19
4	21	15	12	53	1	59	9	53	18	57	23	22
5	21	04	12	33	1	36	10	14	19	11	23	24
6	20	53	12	12	1	12	10	55	19	24	23	26
7	20	41	11	51	0	48	10	56	19	38	23	27
8	20	29	11	30	0	25	11	17	19	51	23	28
9	20	16	11	08	0	01	11	38	20	03	23	29
10	20	03	10	47	North	23	11	48	20	16	23	29
11	19	50	10	25	0	46	12	19	20	28	23	29
12	19	36	10	03	1	10	12	38	20	39	23	28
13	19	22	9	41	1	34	12	58	20	50	23	27
14	19	07	9	19	1	57	13	18	21	01	23	26
15	18	52	9	57	2	21	13	37	21	12	23	24
16	18	37	8	37	2	44	13	56	21	22	23	22
17	18	21	8	12	3	08	14	15	21	32	23	19
18	18	06	7	49	3	31	14	34	21	41	23	16
19	17	50	7	26	3	54	14	52	21	50	23	12
20	17	34	7	03	4	17	15	11	21	59	23	09
21	17	17	6	40	4	41	15	28	22	07	23	04
22	17	00	6	17	5	04	15	46	22	15	23	59
23	16	42	5	54	5	27	16	04	22	23	22	54
24	16	25	5	31	5	49	16	21	22	30	22	49
25	16	07	5	08	7	12	16	38	22	36	22	49
26	15	48	4	44	6	35	16	54	22	43	22	37
27	15	30	4	21	6	57	17	11	22	49	22	30
28	15	11	3	57	7	29	17	27	22	54	22	23
29	14	52	3	34	7	42	17	43	22	58	22	16
30	14	33			8	04	17	58	23	04	22	08
31	14	13			8	26			23	08		

Leap.

A Table of the Sun's Declination.

313

Leap Year.

Sun's Declination 1732. 1736, 1740, 1744, 1748.

Days.	July.		Aug.		Sept.		Octob.		Nov.		Dec.	
	North.		North.		North		South.		South.		South.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	59	14	57	4	06	7	32	17	50	23	09
2	21	51	14	39	3	43	7	54	18	06	23	13
3	21	4	14	20	3	20	8	14	18	22	23	17
4	21	32	14	01	2	57	8	39	18	57	23	20
5	21	23	13	42	2	33	9	01	18	52	23	23
6	21	13	13	23	2	10	9	23	19	07	23	25
7	21	02	13	04	1	47	9	45	19	22	23	26
8	20	51	12	44	1	23	10	07	19	36	23	28
9	20	40	12	24	1	00	10	29	19	49	23	29
10	20	29	12	04	0	36	10	50	20	02	23	29
11	20	17	11	44	0	13	11	11	20	15	23	29
12	20	05	11	24	Sou	10	11	33	20	28	23	28
13	19	53	11	04	0	34	11	54	20	40	23	27
14	19	39	10	43	0	57	12	14	20	52	23	26
15	19	26	10	22	1	21	12	35	21	03	23	24
16	19	13	10	01	1	44	12	55	21	15	23	21
17	18	59	9	40	2	08	13	16	21	25	23	18
18	18	45	9	18	2	31	13	36	21	35	23	15
19	18	30	8	57	2	55	13	55	21	45	23	11
20	18	16	8	35	3	18	14	15	21	54	23	06
21	18	01	8	13	3	41	14	34	22	03	23	01
22	17	45	7	52	4	05	14	54	22	12	22	56
23	17	30	7	29	4	28	15	12	22	20	22	50
24	17	14	7	07	4	51	15	31	22	28	22	44
25	16	58	6	45	5	14	15	49	22	35	22	37
26	16	41	6	23	5	37	16	07	22	42	22	30
27	16	24	6	00	6	00	16	25	22	48	22	23
28	16	07	5	37	6	23	16	43	22	54	22	15
29	15	50	5	15	6	46	17	00	23	00	22	06
30	15	33	4	52	7	09	17	34	23	05	21	57
31	15	15	4	29							21	48

A Table to Reduce the Sun's Declination to any other Meridian than London.

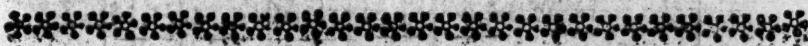
Deg. of Lon.	15	30	45	60	75	90	105	120	135	150	165	180
M.	M	M	M	M	M	M	M	M	M	M	M	M
2	0	0	0	0	0	0	1	1	1	1	1	1
3	0	0	0	0	1	1	1	1	1	1	1	1
4	0	0	1	1	1	1	1	1	1	2	2	2
5	0	0	1	1	1	1	1	2	2	2	2	2
6	0	0	1	1	1	1	2	2	2	2	3	3
7	0	1	1	1	1	2	2	3	3	3	3	3
8	0	1	1	1	2	2	2	3	3	3	4	4
9	0	1	1	1	2	2	3	3	3	4	4	4
10	0	1	1	2	2	2	3	3	4	4	5	5
11	0	1	1	2	2	3	3	4	4	5	5	5
12	0	1	1	2	2	3	3	4	4	5	5	6
13	1	1	2	2	3	3	4	4	5	5	6	6
14	1	1	2	2	3	3	4	5	5	6	6	7
15	1	1	2	2	3	4	4	5	6	6	7	7
16	1	1	2	3	3	4	5	5	6	7	7	8
17	1	1	2	3	4	4	5	6	6	7	8	8
18	1	1	2	3	4	5	5	6	7	7	8	9
19	1	2	2	3	4	5	6	6	7	8	9	9
20	1	2	2	3	4	5	6	6	7	8	9	10
21	1	2	3	3	4	5	6	6	8	9	10	10
22	1	2	3	4	5	5	7	7	8	9	10	11
23	1	2	3	4	5	6	7	7	9	10	11	11
24	1	2	3	4	5	6	7	7	9	10	11	12

Daily Difference of Declination.

No. 19. A Table of Refraction of ☉, ☽ and ☆'s.

	Alt	☉'s	☽'s	☆'s
	Ref.	Ref.	Ref.	Ref.
D.	M.	M.	M.	M.
0	34	33	30	
1	26	25	21	
2	20	20	15	
3	17	17	12	
4	15	15	11	
5	14	14	10	
9	13	13	9	
7	12	13	8	
8	11	12	7	
9	10	11	6	
10	10	11	5	
11	9	10	5	
12	9	9	4	
13	8	9	4	
14	8	8	3	
15	7	8	3	
16	7	7	2	
17	7	7	2	
18	6	6	1	
19	5	6	0	

East } Long. with Decl. {
West } Long. with Decl. {
Incr. } Subtr. but Decl. {
Decr. } Incr. }
Decr. } Add. }



A
T A B L E
O F T H E

SUN's, Rising and Setting, from the
EQUINOCTIAL to the Latitude of 60
Degrees North or South.



A Table shewing the Time of Sun-setting, when the Sun hath North Declination; and the Time of Sun-rising, when the Sun hath South Declination.

Sun's Declination.	The Degrees of Latitude					
	1	2	3	4	5	6
	H.M	H.M	H.M	H.M	H.M	H.M
0	6 0	6 0	6 0	6 0	6 0	6 0
1	6 0	6 0	6 0	6 0	6 0	6 0
2	6 0	6 0	6 0	6 0	6 1	6 1
3	6 0	6 0	6 1	6 1	6 1	6 1
4	6 0	6 0	6 1	6 1	6 1	6 2
5	6 0	6 0	6 1	6 1	6 2	6 2
6	6 0	6 1	6 1	6 2	6 2	6 3
7	6 0	6 1	6 1	6 2	6 2	6 3
8	6 0	6 1	6 2	6 2	6 3	6 3
9	6 1	6 1	6 2	6 3	6 3	6 4
10	6 1	6 1	6 2	6 3	6 4	6 4
11	6 1	6 1	6 2	6 3	6 4	6 5
12	6 1	6 2	6 2	6 3	6 4	6 6
13	6 1	6 2	6 3	6 4	6 5	6 6
14	6 1	6 2	6 3	6 4	6 5	6 6
15	6 1	6 2	6 3	6 4	6 5	6 6
16	6 1	6 2	6 3	6 5	6 6	6 7
17	6 1	6 2	6 4	6 5	6 6	6 7
18	6 1	6 3	6 4	6 5	6 7	6 8
19	6 1	6 3	6 4	6 5	6 7	6 8
20	6 1	6 3	6 4	6 6	6 7	6 9
21	6 2	6 3	6 5	6 6	6 8	6 9
22	6 2	6 3	6 5	6 6	6 8	6 10
23	6 2	6 3	6 5	6 7	6 9	6 10
23, 29	6 2	6 4	6 5	6 7	6 9	6 11

Double the Time of Sun's $\left\{ \begin{array}{l} \text{Setting,} \\ \text{Rising,} \end{array} \right\}$ gives the
Length of the $\left\{ \begin{array}{l} \text{Day.} \\ \text{Night.} \end{array} \right\}$

		The Degrees of Latitude.											
Declination.	Sun's	7		8		9		10		11		12	
		H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0		6	0	6	0	6	0	6	0	6	0	5	0
1		6	0	6	0	6	1	6	1	6	1	6	1
2		6	1	6	1	6	1	6	1	6	2	6	2
3		6	1	6	2	6	2	6	2	6	2	6	3
4		6	2	6	2	6	2	6	2	6	3	6	3
5		6	2	6	3	6	3	6	4	6	4	6	4
6		6	3	6	3	6	4	6	4	6	5	6	5
7		6	3	6	4	6	4	6	5	6	5	6	6
8		6	4	6	4	6	5	6	6	6	6	6	7
9		6	4	6	5	6	6	6	6	6	7	6	8
10		6	5	6	6	6	7	6	7	6	8	6	9
11		6	5	6	6	6	7	6	8	6	9	6	9
12		6	6	6	7	6	8	6	9	6	9	6	10
13		6	6	6	7	6	8	6	9	6	10	6	11
14		6	7	6	8	6	9	6	10	6	11	6	12
15		6	8	6	9	6	10	6	11	6	12	6	13
16		6	8	6	9	6	10	6	12	6	13	6	14
17		6	9	6	10	6	11	6	12	6	14	6	15
18		6	9	6	10	6	12	6	13	6	14	6	16
19		6	10	6	11	6	13	6	14	6	15	6	17
20		6	10	6	12	6	14	6	15	6	16	6	18
21		6	11	6	12	6	14	6	16	6	17	6	19
22		6	11	6	13	6	15	6	16	6	18	6	20
23		6	12	6	14	6	15	6	17	6	19	6	21
23:29		6	13	6	14	6	16	6	18	6	19	6	22

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude, either North or South.

Declinat.	Sun's	The Degrees of Latitude.											
		13		14		15		16		17		18	
		H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
	0	6	00	6	00	6	00	6	00	6	00	6	00
	1	6	01	6	01	6	01	6	01	6	01	6	01
	2	6	02	6	02	6	02	6	02	6	02	6	02
	3	6	03	6	03	6	03	6	03	6	04	6	04
	4	6	04	6	04	6	04	6	05	6	05	6	05
	5	6	05	6	05	6	05	6	06	6	06	6	06
	6	6	06	6	06	6	06	6	07	6	07	6	08
	7	6	07	6	08	6	07	6	08	6	09	6	09
	8	6	08	6	09	6	08	6	09	6	10	6	10
	9	6	09	6	10	6	09	6	10	6	11	6	12
	10	6	10	6	11	6	11	6	12	6	12	6	13
	11	6	11	6	12	6	12	6	13	6	13	6	14
	12	6	12	6	13	6	13	6	14	6	15	6	16
	13	6	13	6	14	6	14	6	15	6	16	6	17
	14	6	14	6	15	6	15	6	16	6	17	6	19
	15	6	15	6	16	6	16	6	18	6	19	6	20
	16	6	16	6	17	6	17	6	19	6	20	6	21
	17	6	17	6	18	6	18	6	20	6	21	6	23
	18	6	18	6	19	6	19	6	21	6	23	6	24
	19	6	19	6	20	6	21	6	23	6	24	6	29
	20	6	20	6	21	6	22	6	24	6	25	6	27
	21	6	21	6	22	6	22	6	25	6	27	6	29
	22	6	22	6	23	6	24	6	27	6	28	6	30
	23	6	23	6	24	6	25	6	28	6	30	6	32
	23.29	6	24	6	25	6	26	6	29	6	31	6	33

Double

Double the Time of Sun's $\left\{ \begin{array}{l} \text{Setting} \\ \text{Rising} \end{array} \right\}$ gives the
Length of the $\left\{ \begin{array}{l} \text{Day.} \\ \text{Night.} \end{array} \right\}$

		The Degrees of Latitude.					
Declinat.	Sun's	19	20	21	22	23	24
		H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
0		6 00	6 00	6 00	6 00	6 00	6 00
1		6 01	6 01	6 01	6 02	6 02	6 02
2		6 03	6 03	6 03	6 03	6 03	6 03
3		6 04	6 04	6 05	6 05	6 05	6 05
4		6 05	6 06	6 06	6 06	6 07	6 07
5		6 07	6 07	6 08	6 08	6 09	6 09
6		6 08	6 09	6 09	6 10	6 10	6 11
7		6 10	6 10	6 11	6 11	6 12	6 13
8		6 11	6 12	6 12	6 13	6 14	6 14
9		6 13	6 13	6 14	6 15	6 15	6 16
10		6 14	6 15	6 16	6 16	6 17	6 18
11		6 15	6 16	6 17	6 18	6 19	6 20
12		6 17	6 18	6 19	6 20	6 21	6 22
13		6 18	6 19	6 20	6 21	6 23	6 24
14		6 20	6 21	6 22	6 23	6 24	6 25
15		6 21	6 22	6 24	6 25	6 26	6 27
16		6 23	6 24	6 25	6 27	6 28	6 29
17		6 24	6 25	6 27	6 28	6 30	6 31
18		6 26	6 27	6 29	6 30	6 32	6 33
19		6 27	6 29	6 30	6 32	6 34	6 35
20		6 28	6 30	6 32	6 34	6 36	6 37
21		6 30	6 32	6 34	6 36	6 37	6 39
22		6 31	6 33	6 35	6 37	6 39	6 41
23		6 33	6 35	6 37	6 39	6 41	6 43
23.29		6 34	6 36	6 39	6 40	6 43	6 45

A Table shewing the Time of Sun-setting, when the Sun hath North-Declination; and the Time of Sun-rising; when the Sun hath South-Declination.

Declination.	Sun's	The Degrees of Latitude.											
		25		26		27		28		29		30	
		H	M	H	M	H	M	H	M	H	M	H	M
	0	6	00	6	00	6	00	6	00	6	00	6	00
	1	6	02	6	02	6	02	6	02	6	02	6	02
	2	6	04	6	04	6	04	6	04	6	04	6	05
	3	6	06	6	06	6	06	6	06	6	07	6	07
	4	6	07	6	08	6	08	6	09	6	09	6	09
	5	6	09	6	10	6	10	6	11	6	11	6	12
	6	6	11	6	12	6	12	6	13	6	13	6	14
	7	6	13	6	14	6	14	6	15	6	16	6	16
	8	6	15	6	16	6	16	6	17	6	18	6	19
	9	6	17	6	18	6	19	6	19	6	20	6	21
	10	6	19	6	20	6	21	6	22	6	23	6	23
	11	6	21	6	22	6	23	6	24	6	25	6	26
	12	6	23	6	24	6	25	6	26	6	27	6	28
	13	6	25	6	26	6	27	6	28	6	29	6	31
	14	6	27	6	28	6	29	6	30	6	32	6	33
	15	6	29	6	30	6	31	6	33	6	34	6	36
	16	6	31	6	32	6	34	6	35	6	37	6	38
	17	6	33	6	34	6	36	6	37	6	39	6	41
	18	6	35	6	36	6	38	6	40	6	42	6	43
	19	6	37	6	39	6	40	6	42	6	44	6	46
	20	6	39	6	41	6	43	6	45	6	47	6	48
	21	6	41	6	43	6	45	6	47	6	49	6	51
	22	6	43	6	45	6	48	6	50	6	52	6	54
	23	6	46	6	48	6	50	6	52	6	54	6	57
	23.29	6	47	6	49	6	51	6	53	6	56	6	59

A Table of the Sun's Rising and Setting.

321

Double the Time of Sun's { Setting } gives the
 Length of the { Rising } Day.
 { Day } Night.

		The Degrees of Latitude.					
Declinat.	Sun's.	31	32	33	34	35	36
		H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
	0	6 00	6 00	6 00	6 00	6 00	6 00
	1	6 02	6 02	6 03	6 03	6 03	6 03
	2	6 05	6 05	6 05	6 05	6 06	6 06
	3	6 07	6 08	6 08	6 08	6 08	6 09
	4	6 10	6 10	6 10	6 11	6 11	6 12
	5	6 12	6 13	6 13	6 14	6 14	6 15
	6	6 15	6 15	6 16	6 16	6 17	6 18
	7	6 17	6 18	6 18	6 19	6 20	6 20
	8	6 19	6 20	6 21	6 22	6 23	6 23
	9	6 22	6 24	6 24	6 25	6 25	6 26
	10	6 24	6 25	6 26	6 27	6 28	6 29
	11	6 27	6 28	6 29	6 30	6 31	6 32
	12	6 29	6 31	6 32	6 33	6 34	6 36
	13	6 32	6 33	6 34	6 36	6 37	6 39
	14	6 34	6 36	6 37	6 39	6 40	6 42
	15	6 37	6 39	6 40	6 42	6 43	6 45
	16	6 40	6 41	6 43	6 45	6 46	6 48
	17	6 42	6 44	6 46	6 48	6 49	6 51
	18	6 45	6 47	6 49	6 51	6 53	6 55
	19	6 48	6 50	6 52	6 54	6 56	6 58
	20	6 51	6 53	6 55	6 57	6 59	7 01
	21	6 53	6 56	6 58	7 00	7 02	7 05
	22	6 56	6 58	7 01	7 03	7 06	7 08
	23	6 59	7 01	7 04	7 06	7 09	7 12
	23:29	6 01	7 03	7 06	7 08	7 11	7 14

C c

A Table

A Table shewing Time of Sun-setting, when the Sun hath North Declination; and the Time of Sun-rising, when the Sun hath South Declination.

Sun's Declination.	The Degrees of Latitude.											
	37		38		39		40		41		42	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6	00	6	00	6	00	6	00	6	00	6	00
1	6	03	6	03	6	03	6	03	6	03	6	04
2	6	06	6	06	6	06	6	07	6	07	6	07
3	6	09	6	09	6	10	6	10	6	10	6	11
4	6	12	6	13	6	13	6	13	6	14	6	14
5	6	15	6	16	6	16	6	17	6	17	6	18
6	6	28	6	19	6	20	6	21	6	21	6	22
7	6	21	6	22	6	23	6	25	6	25	6	25
8	6	24	6	25	6	26	6	28	6	29	6	29
9	6	27	6	28	6	29	6	31	6	32	6	33
10	6	31	6	32	6	33	6	34	6	35	6	37
11	6	34	6	35	6	36	6	38	6	39	6	40
12	6	37	6	38	6	40	6	41	6	43	6	44
13	6	40	6	42	6	43	6	45	6	46	6	48
14	6	43	6	45	6	47	6	48	6	50	6	56
15	6	47	6	48	6	50	6	52	6	54	6	56
16	6	50	6	52	6	54	6	56	6	58	7	00
17	6	53	6	55	6	57	7	00	7	02	7	04
18	6	57	6	59	7	01	7	03	7	06	7	08
19	7	00	7	02	7	05	7	07	7	10	7	12
20	7	04	7	06	7	09	7	11	7	14	7	17
21	7	07	7	10	7	12	7	15	7	18	7	21
22	7	11	7	14	7	16	7	19	7	22	7	25
23	7	15	7	17	7	20	7	23	7	27	7	30
23.29	7	17	7	19	7	22	7	16	7	29	7	32

Double the Time of Sun's $\left\{ \begin{array}{l} \text{Setting,} \\ \text{Rising,} \end{array} \right\}$ gives the
Length of the $\left\{ \begin{array}{l} \text{Day,} \\ \text{Night,} \end{array} \right\}$

Declinat. Sun's	The Degrees of Latitude.											
	43		44		45		46		47		48	
Degrees of Declination.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6	00	6	00	6	00	6	00	6	00	6	00
1	6	04	6	04	6	04	6	04	6	04	6	04
2	6	07	6	08	6	08	6	08	6	09	6	09
3	6	11	6	12	6	12	6	12	6	13	6	13
4	6	15	6	15	6	16	6	17	6	17	6	18
5	6	19	6	19	6	20	6	21	6	22	6	22
6	6	22	6	23	6	24	6	25	6	26	6	27
7	6	26	6	27	6	28	6	29	6	30	6	31
8	6	3	6	31	6	32	6	33	6	35	6	36
9	6	34	6	35	6	36	6	38	6	39	6	41
10	6	38	6	39	6	41	6	43	6	44	6	45
11	6	42	6	43	6	45	6	46	6	48	6	50
12	6	46	6	47	6	49	6	51	6	53	6	55
13	6	50	6	52	6	53	6	55	6	57	6	59
14	6	54	6	56	6	58	7	00	7	02	7	04
15	6	58	7	00	7	02	7	04	7	07	7	09
16	7	02	7	04	7	07	7	09	7	12	7	14
17	7	06	7	09	7	11	7	14	7	17	7	19
18	7	11	7	13	7	16	7	19	7	22	7	25
19	7	15	7	18	7	21	7	24	7	27	7	30
20	7	19	7	22	7	25	7	29	7	32	7	35
21	7	24	7	27	7	30	7	34	7	37	7	41
22	7	28	7	31	7	35	7	39	7	43	7	47
23	7	33	7	37	7	40	7	44	7	48	7	53
23.29	7	36	7	39	7	43	7	47	7	51	7	56

A Table shewing the Time of Sun-setting, when the Sun hath North-Declination; and the Time of Sun-rising, when the Sun hath South-Declination.

Declination	Sun's	The Degrees of Latitude.					
		49	50	51	52	53	54
		H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
0		6 00	6 00	6 00	6 00	6 00	6 00
1		6 05	6 05	6 05	6 05	6 05	6 06
2		6 09	6 10	6 10	6 10	6 11	6 11
3		6 14	6 14	6 15	6 15	6 16	6 17
4		6 18	6 19	6 20	6 21	6 21	6 22
5		6 23	6 24	6 25	6 26	6 27	6 28
6		6 28	6 29	6 30	6 31	6 32	6 33
7		6 32	6 34	6 35	6 36	6 38	6 39
8		6 37	6 39	6 40	6 41	6 43	6 45
9		6 42	6 44	6 45	6 47	6 49	6 50
10		6 47	6 49	6 50	6 52	6 54	6 56
11		6 52	6 54	6 56	6 58	7 00	7 02
12		6 57	6 59	7 01	7 03	7 06	7 08
13		7 02	7 04	7 06	7 09	7 11	7 14
14		7 07	7 09	7 12	7 14	7 17	7 20
15		7 12	7 14	7 17	7 20	7 23	7 27
16		7 17	7 20	7 23	7 26	7 29	7 33
17		7 22	7 25	7 29	7 32	7 36	7 40
18		7 28	7 31	7 35	7 38	7 42	7 46
19		7 33	7 37	7 41	7 45	7 49	7 53
20		7 39	7 43	7 47	7 51	7 56	8 00
21		7 45	7 49	7 53	7 58	8 02	8 08
22		7 51	7 55	8 00	8 05	8 10	8 15
23		7 57	8 02	8 06	8 12	8 17	8 23
23.29		8 00	8 05	8 10	8 16	8 21	8 27

Double
Date

A Table of the Sun's Rising and Setting.

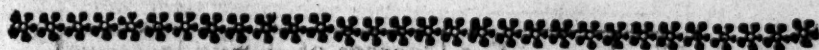
329

Double the Time of Sun's Setting, } gives the
 Rising, }
 Length of the Day.
 Night.

		The Degrees of Latitude.					
Sun's Declination.	Degrees of Declination.	55	56	57	58	59	60
		H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
0		6 00	6 00	6 00	6 00	6 00	6 00
1		6 06	6 06	6 06	6 06	6 07	6 07
2		6 11	6 12	6 12	6 13	6 13	6 14
3		6 17	6 18	6 19	6 19	6 20	6 21
4		6 23	6 24	6 25	6 26	6 27	6 28
5		6 29	6 30	6 31	6 32	6 33	6 35
6		6 35	6 36	6 37	6 39	6 40	6 42
7		6 40	6 42	6 44	6 45	6 47	6 49
8		6 46	6 48	6 50	6 52	6 54	6 56
9		6 52	6 54	6 56	6 59	7 01	7 04
10		6 58	7 00	7 03	7 06	7 08	7 11
11		7 04	7 07	7 10	7 13	7 16	7 19
12		7 11	7 13	7 16	7 20	7 23	7 26
13		7 17	7 20	7 23	7 27	7 30	7 34
14		7 23	7 27	7 30	7 34	7 38	7 42
15		7 30	7 34	7 38	7 42	7 46	7 51
16		7 37	7 41	7 45	7 49	7 54	7 59
17		7 44	7 48	7 52	7 57	8 03	8 08
18		7 51	7 55	8 00	8 05	8 11	8 17
19		7 58	8 03	8 08	8 14	8 20	8 26
20		8 05	8 10	8 16	8 22	8 29	8 36
21		8 13	8 19	8 25	8 32	8 39	8 47
22		8 21	8 27	8 34	8 41	8 49	8 58
23		8 29	8 36	8 43	8 51	9 00	9 09
23 29		8 34	8 41	8 48	8 56	9 05	9 11

A TABLE shewing the Longest Day in every Degree of Latitude.

Longest				Longest				Longest			
Lat.		Day.		Lat.		Day.		Lat.		Day.	
Deg.	H.	M.	S.	Deg.	H.	M.	S.	Deg.	H.	M.	S.
1	12	3	28	26	13	38	00	51	16	19	52
2	12	6	27	27	13	42	44	52	16	30	52
3	12	10	24	28	13	46	16	53	16	41	52
4	11	14	00	29	13	51	36	54	16	54	08
5	12	17	28	30	13	56	16	55	17	07	04
6	12	20	56	31	14	01	12	56	17	21	04
7	12	24	48	32	14	06	08	57	17	36	16
8	12	28	00	33	14	11	12	58	17	52	48
9	12	33	36	34	14	16	24	59	18	10	48
10	12	35	12	35	14	21	52	60	18	30	56
11	12	38	48	36	14	27	20	62	19	18	24
12	12	42	41	37	14	33	04	64	20	24	24
13	12	46	08	38	14	37	36	66	22	20	40
14	12	49	44	39	14	44	56	Deg	D.	H.	M.
15	12	53	28	40	14	51	12	68	42	01	40
16	12	57	20	41	14	57	44	70	64	13	46
17	13	01	04	42	15	04	24	72	82	06	36
18	13	04	46	43	15	11	20	74	96	17	00
19	13	08	56	44	15	18	40	76	110	07	27
20	13	12	48	45	15	26	08	78	122	17	06
21	13	16	48	46	15	34	08	80	134	04	08
22	13	21	04	47	15	42	24	83	151	02	06
23	13	25	04	48	15	51	04	86	166	11	23
24	13	29	20	49	16	00	08	89	181	21	58
25	13	33	35	50	16	09	24	90	187	06	39



T A B L E

OF THE

SUN's Amplitude East or West, from the Equinoc- tial to 60 Degrees of Lati- tude, either North or South.



A Table of the Sun's Amplitude.

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 66 Degrees of Latitude, either North or South.

Declin. Sun's.	The Degrees of Latitude.					
	1.	2.	3.	4.	5.	6.
	D.M.	D.M.	D.M.	D.M.	D.M.	D.M.
0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0
1	1. 0	1. 0	1. 0	1. 0	1. 0	1. 0
2	2. 0	2. 0	2. 0	2. 0	2. 0	2. 0
3	3. 0	3. 0	3. 0	3. 0	3. 0	3. 1
4	4. 0	4. 0	4. 0	4. 0	4. 1	4. 2
5	5. 0	5. 0	5. 0	5. 0	5. 1	5. 1
6	6. 0	6. 0	6. 0	6. 1	6. 1	6. 2
7	7. 0	7. 0	7. 0	7. 1	7. 1	7. 2
8	8. 0	8. 0	8. 0	8. 1	8. 2	8. 2
9	9. 0	9. 0	9. 1	9. 1	9. 2	9. 2
10	10. 0	10. 0	10. 1	10. 1	10. 2	10. 3
11	11. 0	11. 0	11. 1	11. 1	11. 2	11. 3
12	12. 0	12. 0	12. 1	12. 1	12. 3	12. 4
13	13. 0	13. 0	13. 1	13. 1	13. 3	13. 4
14	14. 0	14. 0	14. 1	14. 2	14. 2	14. 4
15	15. 0	15. 0	15. 1	15. 2	15. 3	15. 5
16	16. 0	16. 0	16. 1	16. 2	16. 4	16. 5
17	17. 0	17. 1	17. 1	17. 2	17. 4	17. 5
18	18. 0	18. 1	18. 1	18. 2	18. 4	18. 6
19	19. 0	19. 1	19. 1	19. 2	19. 4	19. 6
20	20. 0	20. 1	20. 2	20. 3	20. 5	20. 6
21	21. 0	21. 1	21. 2	21. 3	21. 5	21. 7
22	22. 0	22. 1	22. 2	22. 3	22. 5	22. 7
23	23. 0	23. 1	23. 2	23. 3	23. 5	23. 8
23.29	23.30	23.30	23.33	23.35	23.37	23.39

When

When } True & } Amplitudes are { the ... { same } —
Magn. }

There's no } Variation of the Compass.
Diff. is the }

Declination.	The Degrees of Latitude.											
	7		8		9		10		11		12	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0.	0	0.	1	0.	0	0.	0	0.	0	0.	0
1	1.	0	1.	0	1.	0	1.	1	1.	1	1.	1
2	2.	1	2.	1	2.	1	2.	2	2.	2	2.	3
3	3.	1	3.	1	3.	1	3.	3	3.	3	3.	4
4	4.	2	4.	2	4.	2	4.	4	4.	4	4.	5
5	5.	2	5.	3	5.	3	5.	5	5.	5	5.	7
6	6.	2	6.	3	6.	4	6.	6	6.	6	6.	8
7	7.	3	7.	4	7.	5	7.	7	7.	8	7.	9
8	8.	3	8.	4	8.	6	8.	8	8.	9	8.	11
9	9.	4	9.	5	9.	6	9.	9	9.	10	9.	12
10	10.	4	10.	6	10.	7	10.	10	10.	11	10.	13
11	11.	5	11.	6	11.	8	11.	11	11.	13	11.	15
12	12.	5	12.	7	12.	9	12.	12	12.	14	12.	16
13	13.	6	13.	8	13.	9	13.	13	13.	15	13.	17
14	14.	6	14.	8	14.	10	14.	14	14.	16	14.	19
15	15.	7	15.	9	15.	11	15.	15	15.	17	15.	20
16	16.	7	16.	10	16.	12	16.	16	16.	19	16.	22
17	17.	8	17.	10	17.	13	17.	17	17.	20	17.	23
18	18.	8	18.	11	18.	14	18.	18	18.	21	18.	25
19	19.	9	19.	12	19.	15	19.	19	19.	22	19.	26
20	20.	9	20.	12	20.	16	20.	20	20.	24	20.	28
21	21.	10	21.	13	21.	17	21.	21	21.	25	21.	29
22	22.	10	22.	13	22.	18	22.	22	22.	27	22.	31
23	23.	11	23.	14	23.	19	23.	23	23.	28	23.	33
23.29	23.	42	23.	46	23.	50	23.	54	23.	59	24.	5

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude, either North or South.

Sun's Declination.	The Degrees of Latitude.											
	13		14		15		16		17		18	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	2	1	2	1	2	1	2	1	2	1	3
2	2	3	2	4	3	4	2	5	2	5	2	6
3	3	5	3	5	3	6	3	7	3	8	3	9
4	4	6	4	7	4	8	4	10	4	11	4	12
5	5	8	5	9	5	10	5	12	5	13	5	15
6	5	10	6	11	6	13	6	15	6	17	6	19
7	7	11	7	13	7	15	7	17	7	19	7	22
8	8	13	8	15	8	17	8	19	8	22	8	25
9	9	14	9	17	9	19	9	22	9	25	9	28
10	10	16	10	19	10	21	10	24	10	28	10	31
11	11	17	11	20	11	23	11	27	11	30	11	34
12	12	19	12	22	12	25	12	29	12	33	12	38
13	13	20	12	24	13	27	13	32	13	36	13	41
14	14	22	14	26	14	30	14	34	14	39	14	44
15	15	24	15	28	15	32	15	37	15	42	15	47
16	16	26	16	30	16	35	16	40	16	45	16	51
17	17	28	17	32	17	37	17	42	17	48	17	54
18	18	30	18	34	18	39	18	44	18	51	18	58
19	19	31	19	36	19	42	19	48	19	54	20	1
20	20	33	20	38	20	44	20	51	21	57	21	4
21	21	35	21	40	21	46	21	53	22	0	22	8
22	22	37	22	43	22	49	22	56	23	4	23	12
23	23	39	23	45	23	51	23	58	24	6	24	15
23.29	24	11	24	17	24	24	24	32	25	40	24	49

A Table of the Sun's Amplitude.

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In counting both Amplitudes from the North.

Observe, If { true } Amp. greatest, at { East } at ☉ { West,
 { Mag. } ☉ rising Var. is { West } sett. { East.

Sun's Declination.		The Degrees of Latitude.											
		19		20		21		22		23		24	
		D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.
0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	3	1	4	1	4	1	5	1	5	1	6	
2	2	7	2	8	2	8	2	9	2	10	2	12	
3	3	10	3	12	3	13	3	14	3	15	3	17	
4	4	14	4	16	4	17	4	19	4	21	4	23	
5	5	17	5	19	5	21	5	23	5	26	5	28	
6	6	21	6	23	6	26	6	28	6	31	6	34	
7	7	24	7	27	7	30	7	3	7	37	7	40	
8	8	28	8	31	8	34	8	38	8	42	8	46	
9	9	31	9	35	9	39	9	43	9	47	9	51	
10	10	35	10	39	10	43	10	48	10	52	10	57	
11	11	38	11	43	11	48	11	53	11	58	11	3	
12	12	42	12	47	12	52	12	58	13	3	13	9	
13	13	46	13	51	13	57	14	3	14	9	14	15	
14	14	50	14	55	15	1	15	8	15	14	15	21	
15	15	53	16	0	16	6	16	13	16	20	16	27	
16	16	57	17	4	17	11	17	18	17	26	17	34	
17	17	1	18	8	18	15	18	23	18	31	18	40	
18	18	5	19	12	19	20	19	28	19	37	19	46	
19	19	8	20	16	20	24	20	33	20	42	20	52	
20	20	12	21	20	21	29	21	39	21	49	21	59	
21	21	16	22	25	22	34	22	44	22	55	23	7	
22	22	20	23	29	23	39	24	50	24	1	24	12	
23	23	24	24	34	24	44	25	55	25	7	25	19	
23.29	24	58	25	8	25	18	25	29	25	41	25	54	

Degrees of Declination.

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude either North or South.

		The Degrees of Latitude.											
Declination.	Sun's	25		26		27		28		29		30	
		D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	6	1	7	1	8	1	8	1	9	1	9	1
2	2	12	2	13	2	15	2	16	2	17	2	18	2
3	3	18	3	20	3	22	3	24	3	26	3	28	3
4	4	24	4	27	4	29	4	32	4	34	4	37	4
5	5	31	5	34	5	37	5	40	5	43	5	46	5
6	6	37	6	41	6	44	6	48	6	52	6	56	6
7	7	43	7	47	7	51	7	56	8	1	8	6	7
8	8	5	8	54	8	59	8	4	9	9	9	15	8
9	9	50	9	1	10	6	10	12	10	18	10	24	9
10	10	3	11	8	11	14	11	21	11	27	11	34	10
11	11	9	12	15	12	21	12	28	12	36	12	44	11
12	12	16	13	28	13	30	13	37	13	45	13	53	12
13	13	22	14	30	14	37	14	45	14	54	14	3	13
14	14	29	15	37	15	45	15	54	16	3	16	12	14
15	15	35	16	44	16	53	17	3	17	12	17	23	15
16	16	42	17	51	18	1	18	11	18	21	18	32	16
17	17	49	18	59	19	9	19	20	19	31	19	43	17
18	18	56	20	6	20	17	20	29	20	41	20	54	18
19	19	2	21	13	21	25	21	38	21	51	22	5	19
20	20	10	22	22	22	34	22	48	23	2	23	16	20
21	21	18	23	30	23	43	23	57	24	12	24	27	21
22	22	24	24	37	24	51	25	6	25	22	25	38	22
23	23	32	25	46	26	1	26	16	26	32	26	49	23
24	24	40	26	54	26	9	26	24	27	40	27	57	24

Amplitudes of { one
different } kind their { Difference } is
the Variation of the Compass.

Sun's Declination		The Degrees of Latitude											
		31		32		33		34		35		36	
Degrees of Declination		D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
		0	0	0	0	0	00	0	00	0	00	0	00
1		1	10	1	10	1	11	1	12	1	13	1	14
2		2	19	2	21	2	23	2	25	2	27	2	29
3		3	30	3	33	3	35	3	38	3	40	3	43
4		4	40	4	43	4	46	4	50	4	53	4	57
5		5	50	5	54	5	58	6	02	6	06	6	11
6		7	00	7	05	7	10	7	15	7	20	7	25
7		8	11	8	16	8	21	8	27	8	33	8	40
8		9	21	9	27	9	33	9	39	9	46	9	54
9		10	31	10	38	10	45	10	52	11	00	11	08
10		11	41	11	48	11	55	12	03	12	12	12	21
11		12	53	13	00	13	09	13	18	13	28	13	39
12		14	02	14	11	14	21	14	32	14	43	14	54
13		15	13	15	23	15	33	15	44	15	56	16	09
14		16	22	16	33	16	45	16	57	17	10	17	24
15		17	34	17	46	17	58	18	11	18	25	18	40
16		18	44	18	57	18	11	19	25	19	40	19	55
17		19	56	20	10	20	24	20	39	20	55	20	11
18		21	07	21	21	21	36	22	53	22	10	22	27
19		22	19	22	34	22	50	23	07	23	25	23	44
20		23	31	23	47	24	04	24	22	24	41	25	00
21		24	43	25	00	25	18	25	37	25	56	26	17
22		25	55	26	13	26	32	26	52	27	13	27	35
23		27	07	27	26	27	46	28	07	28	29	28	52
23.29		27	04	28	00	28	21	28	43	29	07	29	31

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude either North or South.

Sun's Declination.	The Degrees of Latitude.											
	37		38		39		40		41		42	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	00	0	00	0	00	0	00	0	00	0	00
1	1	15	1	16	1	17	1	18	1	20	1	21
2	2	30	2	32	2	34	2	36	2	39	2	41
3	3	45	3	48	3	51	3	54	3	58	4	02
4	5	00	5	04	5	08	5	13	5	18	5	23
5	6	16	6	21	6	26	6	32	6	38	6	44
6	7	31	7	37	7	43	7	50	7	57	8	05
7	8	47	8	54	9	01	9	29	9	17	9	26
8	10	02	10	10	10	19	10	28	10	37	10	47
9	11	17	11	27	11	37	11	47	11	58	12	09
10	12	32	12	43	12	54	13	6	13	18	13	31
11	13	50	14	01	14	13	14	26	14	39	14	53
12	15	06	15	18	15	31	15	45	16	00	16	15
13	16	22	16	35	16	49	17	04	17	20	17	37
14	17	38	17	52	18	08	18	24	18	42	19	00
15	18	55	19	11	19	28	19	45	20	04	20	23
16	20	11	20	28	20	46	21	05	21	25	21	46
17	21	28	21	46	22	06	22	26	22	48	23	10
18	22	46	23	05	23	25	23	47	24	10	24	34
19	24	04	24	24	24	46	25	09	25	33	25	58
20	25	21	25	43	26	08	26	30	26	56	27	24
21	26	39	27	02	27	27	27	53	28	21	28	50
22	27	58	28	23	28	49	29	16	29	45	30	16
23	29	17	29	43	30	11	30	40	31	11	31	43
24	29	57	30	24	30	52	31	22	31	54	32	28

A Table of the Sun's Amplitude.

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If true Ampl. be to the { Right { of the Magn. Ampl. { East.
 { Left { the Variation is { West.

Sun's Declinat.		The Degrees of Latitude.											
		43		44		45		46		47		48	
Degrees of Declination.	Sun's	D. M.		D. M.		D. M.		D. M.		D. M.		D. M.	
0	0	00		0	00	0	00	0	00	0	00	0	00
1	1	22		1	23	1	25	1	26	1	28	1	29
2	3	44		2	47	2	50	2	53	2	56	2	59
3	4	06		4	10	4	15	4	19	4	24	4	29
4	5	28		5	34	5	40	5	46	5	52	5	55
5	6	51		6	58	7	05	7	12	7	20	7	29
6	8	13		8	21	8	30	8	39	8	49	8	59
7	9	35		9	45	9	56	10	06	10	18	10	30
8	10	58		11	09	11	21	17	34	11	47	12	00
9	12	21		12	34	12	47	13	01	13	16	13	31
10	13	44		13	58	14	13	14	28	14	44	15	02
11	15	07		15	22	15	38	15	55	16	15	16	34
12	16	31		16	48	17	09	17	25	17	43	18	06
13	17	55		18	13	18	33	18	54	19	16	19	39
14	19	18		19	39	20	00	20	23	20	47	21	12
15	20	43		21	05	21	28	21	52	22	18	22	45
16	22	08		22	32	22	56	23	23	23	50	24	20
17	23	34		23	59	24	25	24	53	25	23	25	55
18	24	59		25	26	25	54	26	25	26	57	27	31
19	26	25		26	54	27	25	27	58	28	32	29	07
20	27	53		28	23	28	56	29	31	30	07	30	45
21	29	20		29	53	30	27	31	03	31	42	32	23
22	30	48		31	22	31	58	32	37	33	18	34	03
23	32	16		32	51	33	30	34	12	34	56	34	43
23 29	33	03		33	40	34	20	35	03	35	48	36	35

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude, either North or South.

Declination Sun's	The Degrees of Latitude.											
	49		50		51		52		53		54	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	00	0	00	0	00	0	00	0	00	0	00
1	1	31	1	33	1	35	1	37	1	39	1	42
2	3	03	3	06	3	10	3	15	3	20	3	24
3	4	34	4	40	4	46	4	52	4	59	5	06
4	6	06	6	14	6	22	6	30	6	39	6	49
5	7	38	7	48	7	58	8	08	8	19	8	31
6	9	10	9	21	9	33	9	46	10	00	10	15
7	10	42	10	55	11	09	11	24	11	40	11	57
8	12	14	12	29	12	45	13	02	13	21	13	41
9	13	47	14	05	14	24	14	43	15	04	15	26
10	15	21	15	40	16	01	16	23	16	46	17	11
11	16	54	17	16	17	39	18	03	18	29	18	57
12	18	28	18	52	19	18	19	44	20	12	20	43
13	20	06	20	29	20	57	21	26	21	57	22	30
14	21	45	22	06	22	37	23	08	23	42	24	18
15	23	14	23	45	24	18	24	52	25	28	26	07
16	24	51	25	22	25	59	26	36	27	16	27	58
17	26	28	27	03	27	41	28	21	29	04	29	50
18	28	06	28	43	29	24	30	07	30	53	31	42
19	29	45	30	25	31	08	31	55	32	45	33	38
20	31	25	31	08	32	54	33	49	34	39	35	35
21	33	06	33	52	34	41	35	34	36	31	37	32
22	34	48	34	37	36	30	37	27	38	29	39	36
23	36	33	36	26	37	23	39	24	40	29	41	40
23.29	37	26	38	20	38	19	40	23	41	32	42	46

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude, either North or South.

Declination	Sun's	The Degrees of Latitude.											
		55		56		57		58		59		60	
		D.	M.	D.	M.	D.	M.	M.	D.	D.	M.	D.	M.
0	0	00	0	00	0	00	0	00	0	00	0	00	00
1	1	45	1	47	1	50	1	53	1	56	2	00	00
2	3	29	3	34	3	40	3	46	3	53	4	00	00
3	5	14	5	22	5	31	5	40	5	50	6	00	00
4	6	59	7	10	7	22	7	34	7	47	8	01	01
5	8	44	8	57	9	11	9	26	9	43	10	02	02
6	10	30	10	47	11	04	11	22	11	42	12	04	04
7	12	15	12	35	12	56	13	18	13	41	14	06	06
8	14	02	14	24	14	48	15	14	15	41	16	10	10
9	15	49	16	14	16	41	17	10	17	41	18	14	14
10	17	37	18	05	18	35	19	07	19	41	20	18	18
11	19	26	19	56	20	29	21	04	21	43	22	26	26
12	21	15	21	42	22	25	23	04	23	47	24	34	34
13	23	05	23	03	24	23	25	07	23	54	26	45	45
14	24	56	25	37	26	21	27	09	28	01	28	56	56
15	26	49	27	34	28	22	29	14	30	10	31	10	10
16	28	43	29	32	30	24	31	21	32	22	33	27	27
17	30	39	31	31	32	27	33	28	34	32	35	47	47
18	32	35	33	33	34	34	35	40	36	52	38	10	10
19	34	35	35	36	36	43	37	54	39	13	40	37	37
20	36	36	37	42	38	53	40	12	41	37	43	10	10
21	38	39	39	51	41	09	42	34	44	05	45	47	47
22	40	47	42	04	43	27	44	59	46	40	48	32	32
23	42	56	44	19	45	50	47	30	49	21	51	24	24
23.29	44	06	45	32	47	05	48	49	50	44	52	53	53

Days.	Jan.		Febr.		March		April.		May		June.	
	☉ right Ascen.		☉ right Ascen.		☉ right Ascen.		☉ right Ascen.		☉ right Ascen.		☉ right Ascen.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	19	36	21	43	23	29	1	02	3	15	5	20
2	19	40	21	47	23	33	1	26	3	19	5	24
3	19	44	21	51	23	37	1	30	3	23	5	28
4	19	49	21	55	23	40	1	34	3	27	5	32
5	19	53	21	59	23	44	1	37	3	31	5	37
6	19	57	22	3	23	47	1	41	3	35	5	41
7	20	1	22	7	23	51	1	45	3	39	5	45
8	20	5	22	11	23	54	1	48	3	43	5	49
9	20	9	22	15	23	58	1	52	3	47	5	53
10	20	14	22	18	0	02	1	55	3	51	5	57
11	20	18	22	22	0	06	1	59	3	55	6	1
12	20	23	22	26	0	09	2	3	3	59	6	5
13	20	27	22	30	0	13	2	7	4	3	6	9
14	20	31	22	34	0	16	2	11	4	7	6	13
15	20	35	22	37	0	20	2	14	4	11	6	18
16	20	39	22	41	0	24	2	18	4	15	6	22
17	20	43	22	45	0	27	2	22	4	19	6	27
18	20	47	22	49	0	31	2	26	4	23	6	30
19	20	51	22	53	0	34	2	30	4	27	6	34
20	20	55	22	56	0	38	2	33	4	31	6	39
21	20	59	23	0	0	42	2	37	4	35	6	43
22	21	4	23	0	0	45	2	41	4	39	6	47
23	21	8	23	4	0	49	2	45	4	43	6	51
24	21	12	23	11	0	53	2	49	4	47	6	55
25	21	16	23	14	0	56	2	52	4	51	6	59
26	21	20	23	18	1	00	2	56	4	55	7	3
27	21	24	23	22	1	04	3	00	4	59	7	7
28	21	28	23	26	1	07	3	4	5	3	7	11
29	21	32			1	11	3	8	5	7	7	15
30	21	36			1	15	3	11	5	12	7	20
31	21	39			1	18			5	16		

July.

Days.	Jul.		Aug.		Sept.		Octob.		Nov.		Dec.	
	☉ right Ascen.		☉ right Ascen.		☉ right Ascen.		☉ right Ascen.		☉ right Ascen.		☉ right Ascen.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	7	24	9	26	11	20	13	10	15	11	17	16
2	7	28	9	30	11	24	13	14	15	15	17	21
3	7	32	9	34	11	27	13	18	15	19	17	26
4	7	36	9	38	11	31	13	22	15	23	17	30
5	7	40	9	41	11	34	13	26	15	27	17	35
6	7	44	9	45	11	37	13	30	15	31	17	39
7	7	48	9	49	11	42	13	34	15	35	17	43
8	7	52	9	52	11	45	13	38	15	39	17	47
9	7	56	9	56	11	49	13	41	15	43	17	52
10	8	0	9	59	11	51	13	45	15	47	17	57
11	8	4	10	3	11	55	13	49	15	51	18	1
12	8	8	10	7	11	59	13	53	15	54	18	6
13	8	12	10	11	12	3	13	57	15	59	18	10
14	8	16	10	15	12	7	14	0	16	3	18	15
15	8	20	10	18	12	10	14	2	16	8	18	20
16	8	24	10	22	12	14	14	8	16	12	18	24
17	8	28	10	26	12	18	14	13	16	16	18	29
18	8	32	10	29	12	22	14	16	16	20	18	34
19	8	36	10	33	12	25	14	20	16	24	18	38
20	8	40	10	36	12	28	14	24	16	29	18	42
21	8	44	10	40	12	32	14	28	16	33	18	46
22	8	48	10	44	12	36	14	32	16	37	18	50
23	8	52	10	48	12	39	14	36	16	41	18	55
24	8	56	10	51	12	43	14	39	16	45	18	59
25	8	59	10	54	12	47	14	43	16	50	19	4
26	9	3	10	58	12	50	14	47	16	54	19	8
27	9	7	11	2	12	54	14	51	16	58	19	12
28	9	11	11	5	12	58	14	55	17	3	19	17
29	9	15	11	9	13	2	14	59	17	7	19	21
30	9	18	11	12	13	6	15	3	17	12	19	26
31	9	22	11	16			15	7			19	31

A TABLE shewing the Semi-diurnal Arks, Seasons for Observing, Right Ascension and Declination of some Principal Fixed Stars.

Names of the Stars.	Magn.	Semi-diurnal Arks.	Season.	Right Ascen.	Declin.
	H. M.	M. B.	H. M.	D. M.	
Pole-Star.	2	set. not	Dec. 5	00.31	87.33N
Upper of the Pointers.	2	D ^o .	Feb. 17	10.43	03.32N
Lower of the Pointers.	2	D ^o .	Feb. 16	10.41	58. 8N
Bright * in the N ^o . Crown.	2	D ^o .	May 3	15.21	47.43N
<i>Arcturus.</i>	1	7.55	Apr. 12	14.02	20.54N
Bull's Eye, <i>Aldebaran.</i>	1	7.22	Nov. 17	4.18	15.50N
Brightest 7 Stars, <i>Pleiades.</i>	3	8.10	Nov. 6	3.29	22.55N
<i>Orion's</i> Right Shoulder.	2	6.31	Dec. 6	5.39	7.18N
First in <i>Orion's</i> Belt.	3	5.55	Dec. 1	5.15	0.35 S
<i>Orion's</i> Right Foot Regal.	1	5.06	Nov. 27	5.01	8.37 S
Mouth of the Great Dog <i>Syrus.</i>	1	4.34	Dec. 17	6.32	16.20 S

Head } Of the Crostiers or Crofs; when the Star A is
 * B } perpendicular to Star B, then it is fit time
 * * } to observe the Crofs's Foot A. This is most
 * A } commonly used by our West, East-Indies; and
 Foot } Guiney Navigators.

A Table for the Crostiers.

	Rt. Asc.	Declin.	N ^o .
	H. M. S.	D. M. S.	
The Preceding of the two Middle- most in the Crofs	12.01.29	57.10.37	3
The Southermost of the Crofs	12.12.20	61.31.16	2
The Northermost of the Foot	12.16.41	55.39.10	2
The following or Eastermost of the Four	12.26.03	58.05.57	1



A Table of the Latitude and Longitude of the principal Harbours, Headlands and Islands in the World; Corrected by the latest and best Observations; the Beginning of the said Longitude being accounted from the Meridian of LONDON.

N. B. The Latitude and Longitude of any Island set down hereunder, is meant of the Middle thereof, except some part of it be express'd or nam'd.

Places Names.	Nor. Latit.	West Lon.	Places Names.	Nor. Latit.	East Lon.
The Coast of ENGLAND.	D.M.	D.M.	The Coast of ENGLAND.	D.M.	D.M.
B erwick	55.50	01.39	Lynn	52.56	00.29
Newcastle	54.58	01.30	Wells	53.07	01.00
Shelles	55.02	01.20	Blackney	53.24	00.55
Sunderland	54.52	01.20	Cromer	53.10	01.07
Hartlepool	54.40	00.55	Winterton	53.02	01.22
Whitby	54.35	00.40	Tarmouth	52.45	01.40
Scarborough	54.20	00.03	Alborough	52.24	01.25
Stockton	54.33	01.25	Orfordness	52.20	01.11
Hull	53.45	00.28	Ipswich	52.14	01.00
	Nor. Latit.	East Lon.	Harwich	52.11	01.18
			Colehester	52.04	00.58
Flamborough Head	54.08	00.11	LONDON	51.32	00.00
Burlington	54.00	00.06	Rocheſter	51.28	00.25
Spurn	53.35	00.30	Margate	51.29	01.10
Grimesby	53.39	00.56	North Foreland	51.28	01.10
Boston	53.09	00.10			

Places

Places Names.	Nor. Latit.	East. Lon.	Places Names	Nor. Latit.	West Long.
The Coast of England	D.M.	D.M.	Coast of England from the Lizard to Holy Head.	M.D.	D.M.
<i>Sandwich</i>	51.27	1. 09	<i>Falmouth</i>	50.12	5. 12
<i>The Downs</i>	51.25	1. 21	<i>Lizard</i>	49.55	5. 14
<i>South Foreland</i>	51.12	1. 20	<i>St. Mary's Scilly</i>	49.57	6. 45
<i>Riprap</i>	51.53	1. 25	<i>Lands End</i>	50. 6	6. 0
<i>Dover</i>	51.15	1. 18	<i>Gulf</i>	50. 6	6. 6
<i>Dungeness</i>	51. 00	0. 51	<i>Seven Stones</i>	50. 5	6. 40
<i>Rye</i>	51. 30	0. 45	<i>Hartland Point</i>	51. 6	4. 35
<i>Beachy</i>	50.48	0. 25	<i>Londey Isle</i>	51.20	4. 40
	Nor. Latit.	West Lon.	<i>Mort Bay</i>	51.12	4. 40
			<i>Bristol</i>	51.32	2. 35
			<i>Swansey</i>	51.40	4. 25
			<i>Caldy Island</i>	51.33	5. 14
			<i>Milford</i>	51.45	5. 15
<i>Shoreham</i>	50.55	0. 17	<i>St. David's Head</i>	51.55	5. 22
<i>Portsmouth</i>	50.48	1. 00	<i>Barsey Isle</i>	52.40	5. 10
<i>Dunnose, I. Wight.</i>	50.38	1. 23	<i>Liverpool</i>	53.20	3. 10
<i>Pool</i>	51. 01	1. 50	<i>Westchester</i>	53.37	4. 20
<i>Weymouth</i>	50.43	2. 40	<i>Lancaster</i>	54.40	3. 35
<i>Portland</i>	50.30	2. 48	<i>White Haven</i>	54.10	3. 50
<i>Obiddock</i>	50.47	3. 00	<i>Isle of Man W. End</i>	53.45	5. 0
<i>Lime</i>	50.45	3. 14	<i>Holy Head</i>	53.23	4. 40
<i>Topsham</i>	50.37	3. 27			
<i>The Berry Head</i>	50.23	3. 49			
<i>Torbay</i>	50.25	3. 38	Sea-Coasts of Scotland.		
<i>Dartmouth</i>	50.27	3. 36			
<i>Start Point</i>	49.50	3. 45	<i>Glasgow</i>	55.53	4. 5
<i>The Eddystone</i>	50.07	4. 30	<i>North Part of Sky-Island.</i>	57.50	5. 21
<i>Plymouth</i>	50.36	4. 13			
<i>Ramhead</i>	50.14	4. 35			
<i>Fox</i>	50.25	4. 30			

A Table of Latitude and Longitude.

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Places Names.	Nor. Latit.	West Lon.	Places Names.	Nor. Latit.	West Lon.
Coast. of Scotland	D.M.	D.M.	Sea-Coasts of Ireland.	D.M.	D.M.
N. Part Lewis Isle	58.20	7. 15	Mixon Head	51.15	11.30
St. Kilda	58. 2	10. 5	Old Head Kinsal	51.35	8. 58
Farra Head	58.23	5. 5	Cape Clear	51.10	10.30
Sbetland S. Point	59.52	3. 39	Cork	51.49	9. 39
Fair Isle	59.30	3. 20	Waterford	52. 7	7. 52
Orkney Isles	59.13	3. 32	Wexford	52.13	7. 16
Car-Nefs	58.47	2. 6	Lambay	53.24	7. 30
Buchan Nefs	57.55	1. 20	DUBLIN	53.20	7. 6
Aberdeen	57.24	1. 37			
Dundee	56.30	2. 36			
Edinburgh	55.57	2. 46	Sea-Coasts of Holland & Flanders.		East Lon.
Leith	56. 0	2. 55			
Sea-Coasts of Ireland			Heligbland	54.28	8. 35
			Scaw	57.26	10.10
			Hamborough	53.41	10.24
			Bremen	53.50	8. 0
			Emden	53. 5	8. 0
Fair Foreland	55. 5	6. 30	Ameyland	53.40	6. 40
London-Derry	54.55	8. 0	Schelling	53.25	5. 50
Belfast	54.36	6. 50	The Fly	53.18	5. 35
Island Torre	55. 8	8. 30	The Texel	53.10	4. 59
Isles of Arran	54.48	8. 59	Amsterdam	52.21	4. 51
Stags of Bro. Haven	54. 7	10. 5	Rotterdam	51.55	4. 21
Sling Head	53.20	11.15	Antwerp	51.17	4. 32
Galloway.	53. 5	9. 20	The Brill	51.56	4. 10
Gally or Doens Hd.	52.40	9. 30	Middleburgh	51.48	4. 0
Lupis's Head	52.24	10.15	Sluys	51.19	3. 50
Limerick	52.22	9. 48	Ostend	51.30	3. 5
Blasques	52. 0	11.55	Dunkirk	51.18	2. 25
Skillocks	51.30	11.55	Callis	50.57	2. 0
Cow and Calf	51.22	10.36	Diep in France	49.56	1. 6

Places

Places Names.	Nor. Latit.	West Lon.	Places Names.	Nor. Latit.	East Lon.
Coast of France and Portugal.	D.M.	D.M.	Coast of Spain.	D.M.	D.M.
Cape de Hague	49.46	2. 06	Cape Paul	37.58	0.22W.
Caskets	49.50	2. 32	Cape Murzin	39.00	0.28E.
Guernsey	49.36	2. 40	Alicant	38.30	0. 35
Jersey	49.20	2. 19	Barcelona	41.30	2. 21
St. Maloes	48.35	1. 5	Marseilles	43.20	5. 15
Morlaix	48.37	3. 50	Toulon	43. 6	5. 40
Ushant	48.30	5. 5	Genoa	44.25	8. 40
Brest	48.23	4. 24	Legborne	43.18	10.29
Penmark	47.48	4. 15	Civita Vecchia	41.46	12. 0
Bell Isle	47.20	3. 10	Rome	41.51	12.28
Nants	47.14	1. 49	Naples	41. 5	14.28
Rechel	46.10	1. 14	Cape Sparta-vento	38. 0	16.58
Bourdeaux	44.50	0. 24	C. Collone	32.10	18. 0
Bilboa	43.30	3. 0	Gallipoli	40. 8	18.39
Cape Ortegel	44.02	7. 40	C. St. Mary	39.56	19. 0
Cape Coruna	43.28	9. 20	Anconn	43.31	14.40
Cape Finister	43.06	10. 0	Venice	45.18	13.10
Porta Port	41.18	9. 20	Lepanto	38.20	21.55
Burlings	39.39	10.15	C. Matapan	36.35	22.20
Rocks of Lisbon	48.54	10.20	C. St. Angelo	36.41	23.20
Cape St. Vincent	37.00	9. 32	Athens	38. 0	24.29
Cape St. Maria	36.58	9. 18	C. Martelo, S.P. 2	38. 0	25.43
Cadiz	36.16	7. 0	of Negropont. 5		
C. Trefalgar	36. 5	6. 30	C. Monte Sancto	40. 5	26. 5
Coast on the main			Gallipoli	40.30	27.58
Continent with-			Constantinople	41. 7	33. 0
in the Straits.			Smyrna	38.30	27.25
			Ephesus	37.54	27.15
			Antiochetta	36.40	31.37
Gibraltar	36.11	5. 5	Scanderoon	36. 0	35.58
Malaga	36.50	4. 7	Tripoli	34.40	35.40
Cape de Gat	37.03	2. 2	Alexandria	31. 7	30.50

Places

A Table of Latitude and Longitude.

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Places Names.	Nor. Latit.	East. Lon.	Places Names.	Nor. Latit.	East. Lon.
In the Straits.	D.M.	D.M.	Isles in the Straits.	M.D.	D.M.
C. Rufato	33.15	21.55	Zant	37.47	22.10
C. Misorato	32.42	16.23	Modon. Morea	36.52	21.32
C. Bona	37.5	10.0	Lemnos	29.50	25.27
Bona	37.0	7.0	Scio	38.20	23.31
Algier	36.40	3.5	C. St. John, W. end		
C. de tres forcas	35.34	12.25 W	of Candy.	35.20	23.27
Tetuan	35.28	5.52	C. Solomon. E. end		
Ceuta	35.55	5.47	of Candy.	35.25	26.31
Tangier	35.55	6.14	Rhodes City	36.40	38.0
			W. end of Cypress	35.21	31.35
			E. end of Cypress.	35.35	34.25
Islands within the Straits.	East. Lon.		Coast of Barbaria and Guiney.	West Lon.	
Alboran	36.10	2.0 W.			
Formentaria	38.44	1.91			
Ivoia	39.51	30	C. Sparsel	35.46	5.55
Majorca City	39.48	2.49	Saltee	33.43	6.30
Minorca, P. Maon	40.24	25	C. Canrin	32.16	9.20
S. End of Sardinia	38.46	9.10	C. de Geer	30.04	10.10
N. End of Sardinia	41.0	10.1	C. Bajador	26.12	14.20
N. End of Corsica	42.57	9.45	C. Olerado	23.41	15.50
Gorgona	43.34	9.38	C. Blanco	20.35	16.55
Capita	43.09	40	Senegal	15.16	15.40
Lilboa	42.44	10.5	C. de Verde	14.30	16.26
Messina	38.22	16.25	River Gambia	13.16	15.20
Maritimo	38.12	11.55	Serralion	8.36	12.15
C. Passero	36.48	16.4	Monfénado	6.52	20
Malta	36.10	14.29	C. Palmos	4.35	38
Corfu	39.45	20.42	Fague Fague	4.16	2.30
Chefalonis	38.15	21.49	Affene	4.15	1.0

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Places
Places

<u>Places Names.</u>	Nor. <u>Latit</u>	East Lon.	<u>Places Names.</u>	Nor. <u>Latitude</u>	West Lon.
<u>Guiney Coast.</u>	D.M.	D.M.	<u>Western Islands</u>	D.M.	D.M.
Cape Corce	4. 40	3. 10	Tercera	38. 53	24. 49
C. Three Points	4. 13	0. 45	St. Michael	38. 6	22. 32
River Volto	5. 40	3. 30	St. Maries	37. 0	22. 17
R. Formosa	7. 07	. 40			
C. Formosa	4. 40	8. 0			
New Callibar	4. 12	10. 25			
Old Callibar	3. 18	11. 32	Canary Isles.		
R. Camerones	4. 2	13. 10			
R. de Angra	0. 49	13. 15			
	South Latit.		Porto Santa	32. 50	15. 50
			Madera W. end	32. 17	17. 22
			Ferro	28. 0	18. 12
			Palma	28. 50	18. 0
			Gomero	28. 8	17. 26
			Teneriff	28. 20	16. 45
Lepas	1. 5	12. 20	Canaries	27. 56	15. 30
River Congo	5. 4	15. 27	Forsaventura	27. 54	13. 24
Angola	8. 51	15. 56	Lancerosa	28. 32	12. 54
Cape Negro	16. 8	14. 46			
C. St. Thomas	23. 10	14. 23			
Secos	28. 56	15. 32	Cape de Vera Isles.		
C. Bona Esperance.	34. 25	17. 25			
<u>Western Islands.</u>	Nor. Latit.	West Lon.	St. Antonio	17. 10	25. 20
			St. Vincent	16. 55	25. 10
			St. Lucia	16. 45	24. 58
			St. Nicholas	16. 40	24. 22
Corvo	40. 5	29. 55	Ile de Sal	17. 0	22. 13
Flores	39. 40	29. 50	Ile May	15. 0	22. 16
Fyal	38. 53	27. 16	St. Fago	15. 20	23. 10
Pico	38. 32	26. 31	Brava	14. 35	24. 38
St. George	38. 56	26. 10	Fuego	14. 42	24. 0
Gratiosa.	39. 30	38. 15	Bonavista	16. 5	21. 55

Places

A Table of Latitude and Longitude.

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Places Names.	South Latit.	West. Lon.	Places Names.	Nor. Latit.	East Lon.
Southern Isles.	D.M.	D.M.	East India.	D.M.	D.M.
<i>St. Matthew's</i>	1. 40	3. 5	<i>Buffera</i>	30. 0	49. 5
<i>Ascension</i>	8. 10	12. 5	<i>Surrae</i>	22. 8	73. 25
<i>St. Helena</i>	16. 6	5. 4	<i>Goa</i>	13. 22	74. 37
			<i>Calcutte</i>	11. 17	75. 54
	Nor.	East	<i>Cochin</i>	9. 58	76. 45
	Latit.	Lon.	<i>C. Comarins</i>	7. 50	78. 25
			<i>Fort St. George</i>	13. 8	81. 42
			<i>Dew Point</i>	15. 50	92. 5
			<i>Visegapatam</i>	17. 40	85. 7
<i>Fernandepo</i>	2. 35	11. 55	<i>Bombay Isle</i>	19. 0	73. 15
<i>Princips</i>	1. 25	11. 0	<i>C. Palmyra</i>	20. 45	88. 10
<i>St. Thomas</i>	0. 09	9. 58	<i>Bengal</i>	22. 27	91. 49
<i>Annabona</i>	1. 25	9. 28	<i>C. Negrais</i>	16. 23	93. 0
			<i>Malacca</i>	2. 21	101. 22
			<i>Cambodia Entrance</i>	10. 30	105. 20
<i>Coast of the Main</i>	South		<i>Siam Entrance</i>	13. 10	101. 1
<i>Continent in the</i>	Latit.		<i>Cochin</i>	18. 25	103. 15
<i>East-Indies.</i>			<i>Cansam</i>	23. 30	113. 20
			<i>Amey Isle</i>	24. 25	116. 55
			<i>Lampo</i>	30. 10	120. 25
			<i>Namquin</i>	32. 55	120. 5
<i>C. Lagullas</i>	35. 35	17. 25			
<i>C. Corientes</i>	23. 52	35. 35			
<i>Mosambique</i>	15. 5	40. 30			
<i>River de Fugos</i>	0. 0	41. 15			
	Nor.		<i>Islands in the</i>		
	Latit.		<i>East Indies.</i>		
			<i>Madagascar, or St.</i>		
			<i>Lawrence South-</i>		
<i>Cape Bassos</i>	4. 0	49. 50	<i>End</i>	26. 6	46. 20
<i>C. Guardafou</i>	11. 50	52. 30	<i>North-End</i>	12. 10	50. 10
<i>C. Rosulgar</i>	22. 27	60. 45	<i>Mayetta</i>	13. 10	45. 45
<i>Cape Mucca</i>	26. 56	57. 10	<i>Mehilla</i>	12. 15	43. 41

Places Names	Nor. Latit.	East Lon.	Places Names	South Latit.	East Lon.
East India Islands.	D.M.	D.M.	Isles in the East Indies.	D.M.	D.M.
Malhe	11.15	60.30	Nassau Isle	2. 4	98.32
Comero	11.50	43.44	Bencola	3. 50	101.13
St. Juan de Nova	17 30	42.35	Sumatra the S. E. End	5. 42	104. 4
Mauritius	20. 5	55. 5	Engano	5. 40	100.53
Digo Royes	19.45	61.35	Selam	8. 20	102.13
Rominas de Castel-amos	29. 5	66.56	Princes Isle	6. 30	104. 2
Amsterdam	39.50	74.24	Bantam on Java	5. 47	105.11
St. Brandon	16.38	64.30	Batavia	5. 37	106.27
Digo-gratiosa	8. 42	69. 5	Java East end	8. 35	112.27
Quabella	3. 49	52.39	Straits of Sundy	5. 52	104.18
Bassos de Chagos	5. 5	70.25	Banca South End	3. 25	106.37
Tas de Digo Rays	0. 0	72. 5	Borneo South Point	4. 14	112.52
	South Latit.		Bandy Isles	5. 5	126.37
			Celebes South End	6. 0	117.27
				Nor. Latit.	
Maldivia } N. end	7. 5	73. 5			
} S. end	1. 0	76.15			
Mallique	9. 0	73.15	Celebes North End	1. 40	121.30
Saccatra	12.28	55.39	Mindano W. Point	6. 30	118.35
Abdeleur	12.10	54.23	Borneo N. Point	7. 10	112.45
C. Gallo in Zeloan	6. 7	80.45	Luconio { S. Point	12.30	120.50
	Nor. Latit.		{ N.E. Pt.	18.35	119. 5
			Arain { W. Point	19.30	108. 6
			{ E. Point	19.55	111.16
			Formosa { S. Point	22. 0	119.30
Tas de Amber	0. 0	52.30	{ N. Point	25.32	120.25
Andaman	43. 0	91.25	Piscadore Isles	23 30	117.35
Nicobar	7. 5	92.55	Island Chusan	30.38	120.35
Sumatra the N.W. End	5. 28	93.45	Japan { S.E. Point	39.50	135.15
Yerkins Isle	2. 22	94. 7	{ S.W. Point	39.10	126.55

Places

Places Names	Nor. Latit.	West Long.	Places Names.	South Latit.	West Lon.
The Coast of America in the South Sea.	D.M.	D. M.	Coast of Brazil, in South-America.	D. M.	D.M.
C. St. Sebastian	42.40	129.55	Buenas Ares or River Plata	36, 10	57, 30
C. St. Luca	23.25	111.56	River Grand	31, 55	51, 40
C. Corientes	19.40	110.30	St. Katherine's Isle	28, 04	7, 50
Aquapulco	17. 0	106. 8	Cape Friso	23, 10	42, 56
Aquatulco	15.27	101. 3	Spirito Santo	19, 58	42, 0
Guatemala	14.25	96 0	P. Segura	16, 22	40, 58
Panama	8. 56	82 18	Bay Todos Sanctus	13, 04	40, 35
Bay Bonaventuro	3. 28	80 6	R. St. Francisco	10, 55	37, 46
Isles of Gallopego	0. 09	90 10	Cape St. Augustine	8, 53	35, 38
	South Latit.		Cape Roque	5, 03	35, 52
			Friscan de Cunba	37, 51	35, 38
			Trinidad	0 3	30. 0
Cape del Ajugo	16.38	88 50			
Cima	12.30	73 30	Coast on the Main Continent in the West Indies.	Nor. Latit.	West Lon.
Arica	18.12	74 10			
La Serena	24.40	76 32			
I. Juan or Fernando	23.20	86 48			
Baldivia	39.35	81 20			
Port Steven	46.50	82 36			
Cape Victory	52.15	83 20	R. Amazonas entr.	0, 04	49, 0
Cape Horn	57.58	79 55	North Cape	2, 54	49, 55
			Surnam	6, 05	56, 55
			Oroonoque	8, 15	59, 5
			C. Coquibaca	12, 15	70, 40
			Carthagena	10, 50	75, 0
			Scot Settlement	8, 30	58, 45
			Nicarague Entr.	11, 15	85, 5
			Cape Catocha	21, 22	88, 55
			Campeche	19, 20	93, 5
			La vera Cruz	19, 15	100. 25
			Escondide	18, 20	99, 0
			Cape Florida	24, 48	81, 55
			Mississippi R. Mouth	28, 30	96, 10
			Apalachia	29, 47	85, 48

Places

Place Names.	Nor. Latit.	West Lon.	Places Names.	Nor. Latit.	West Lon.
The Caribbees, or West India Islands.	D.M.	D.M.	Babama Isles.	D.M.	D.M.
Trinidad	10, 0	60, 5	Babama Isle	27, 5	78, 58
Tobago	11, 10	59, 20	Abaca, S. Point	25, 50	77, 20
Granada	12, 7	60, 30	Harbour Island	25, 40	76, 35
Barbadoes	13, 12	59, 22	Andros, N. Point	25, 15	79, 0
St. Lucia	13, 52	59, 17	Providence	25, 0	77, 45
Martinico	14, 48	58, 25	Illasbera, S. Point	24, 30	76, 12
Dominico	15, 35	58, 27	Car Island	24, 25	75, 20
Marigalante	15, 53	58, 20	Watling Island	24, 7	74, 50
Guadalupa	16, 15	59, 23	Rum Key	23, 45	75, 5
Monserat	16, 40	59, 35	Exuma	23, 25	76, 7
Antegoa	17, 0	59, 30	Crooked Isle, N. Pr.	23, 3	74, 0
Nevis	17, 6	60, 18	Atkin's Key	22, 0	74, 15
St. Christophers	17, 22	60, 35	Metapervoux	21, 57	74, 40
Barbuda	17, 43	59, 25	Atwood's Keys	23, 9	73, 30
St. Bartholomew	17, 54	60, 45	French Keys	22, 40	73, 35
S. Martin's	18, 5	60, 49	Mayaguana	22, 35	73, 0
Anguilla	18, 13	60, 55	Hogsties	41, 15	73, 50
Virgins	18, 23	62, 22	Hyneago	20, 57	73, 30
St. Cruz	17, 38	62, 35	Concos Bank, N. Point	21, 50	71, 15
Bique	18, 0	63, 15	Turks Island	21, 35	70, 8
St. Thomas	18, 30	63, 22	Abrolbo, N. Point	21, 40	68, 40
Tortuga	20, 15	72, 54	Plate Wreck	20, 4	68, 10
Port Rico or St. John's	18, 33	64, 20	Coast of Carolina, Virginia, Maryland, Pennsylvania, New-England, and New-found-land.		
St. Dominica Hispaniola	18, 15	68, 50			
P. Royal Jamaica	18, 0	77, 3			
East end of Cuba	20, 20	74, 5			
Havana	22, 50	83, 30			
Bay Honda	22, 34	84, 40			
C. St. Antonia	21, 50	86, 32	Charles Town upon Ashby-River	32, 40	78, 50

Places

A Table of Latitude and Longitude.

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Places Names.	Nor. Latit.	West Lon.	Places Names.	Nor. Latit.	West Lon.
Coast of Virginia, &c.	D.M.	D.M.	Coast of Hudson's Bay and Straits.	D.M.	D.M.
Cape Hatteras	35, 10	74, 25	Cape Walsingham	63, 15	77, 40
Cape Henry	37, 0	74, 30	Mansfield Isle	62, 20	80, 50
Cape Charles	37, 14	74, 35	Cape Jones	55, 3	79, 15
Cape Hinloper	39, 4	73, 25	Rupert's River	51, 16	79, 55
Long Island	40, 50	70, 40	Albany River	52, 32	84, 7
New York	41, 0	72, 5	The Cuddy	54, 15	82, 0
Cape Cod	42, 10	67, 45	C. Henrietta Maria	55, 5	84, 2
Boston	42, 35	68, 50	Port Nelson	57, 5	92, 47
Cape Sable	43, 45	63, 25	Cape Churchill	59, 0	92, 57
Island Sable	44, 30	59, 5	C. Southampton	61, 57	88, 30
Cape Britain	46, 20	58, 15	Shark Point	64, 27	83, 20
Quebeck	47, 15	68, 10	Nottingham Isle	63, 38	79, 47
Bay of Brest	52, 10	55, 0	Q Ann's Foreland	63, 32	73, 57
Bell Island	52, 5	54, 10	Resolution Isle	61, 55	65, 50
Cape St. John	50, 9	52, 35	Cape Farewel	59, 10	46, 35
Penguin Isle	50, 15	53, 10			
Cape Bonavista	49, 11	52, 3			
Trinity Bay	48, 27	52, 15			
Conception Bay	47, 53	52, 0	Sea-Coasts in the		East
St. John's Harbour	47, 28	51, 25	Sound and Baltic Sea.		Lon
Bay of Bulls	47, 40	51, 9			
Cape Race	46, 30	51, 25			
Cape St. Mary	47, 10	53, 20			
Placentia	47, 57	53, 0			
Cape Roy			Maerden	58, 25	9, 5
			Lærwick	58, 54	9, 20
			Christiana	59, 10	9, 45
			Maesterland	57, 58	11, 45
			Gottenberg.	57, 33	12, 25
			Elfinore	56, 0	12, 32
			Copenhagen	55, 44	12, 35
			Valsteborn	55, 20	12, 55
			Kalmer	56, 40	16, 40
			Stockholm	59, 20	18, 25
Coast of Hudson's Bay and Straits.					
Buttons Isle	60, 5	66, 50			
Cape Charles	62, 35	75, 20			

Places

Places Names.	Nor. Lirit	East Lon.	Places Names	Nor. Latit.	East Lon.
Sea-Coast in the Baltick.	D.M.	D.M.	Coast of Norway.	D.M.	D.M.
Vyburgh	60,20	29,26	Sweetnose	68, 8	34,40
Petersburgh	59,25	29,50	Cross Island	66,31	36,33
Narve	58,39	28,14	Archangel-Bar	65, 5	35,50
Revel	59, 0	24,45			
Riga	56,50	24,50			
Derwinda	57,20	22, 0			
Coningsberg	55, 0	20,20	Coast of the Northern Isles, Nova-Zembla, Iceland, and Greenland.		
Dantzick	54,22	19, 0			
Wisbuy in Gotland	57,37	18,50			
Bornholm	55,37	14,53			
Straelsound	54,45	13,20			
Lubeck	52,25	11, 5	Catsnose	65,43	35,14
Anout	56,42	10,58	Cape Candenose	69,27	42,39
Lefou	57, 5	10,40	Fretem Borrough	69,55	62, 5
Staw	57,26	10,10	Admiralty Island	75, 5	59,50
			Bear Isle	74,35	18, 5
			Hope Isle	76,22	22, 0
			Lees Foreland	78, 5	23,25
			Helies Sound	79,15	12, 5
			Halcuit Head-land	79,55	12, 0
			Point Look out	76,40	16,25
			Cape Cold, N. end	79, 0	10,32
			Fair Foreland	79,18	10,50
			Bell Sound	77,34	13,39
			Horn Sound	77,23	14,20
			Isles of Fero	62, 65	0
			Grims Island	66,51	17,45
			Merch. Foreld.	63,20	14, 5
			Whales Back	65,27	10, 5
			Sound Royal	66,22	14,15
			Bargazar Point	66,30	11,12
			Halliford	64,34	24,15
Sea-Coasts from the Naze of Norway to Arch-Angel.					
Naze of Norway	57,50	7, 22			
Northbergen	60,16	5, 40			
Standland	62,10	4, 38			
Dronton	64, 0	10,40			
Loesfort S.W. Point	67,47	9, 35			
Fromsund	70,18	16, 9			
Surroy	71, 5	18,40			
North-Cape	71,25	22, 0			
Kildun	69,32	30,15			

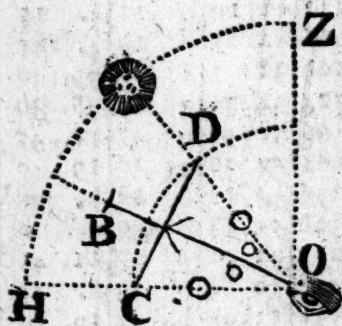
A Table of the Latitudes, Bearing and Distance, Difference of Longitudes, and Difference of Meridians, from LONDON, of several Eminent Cities and Towns.

Places Names.	Points of Bearing.	Dist	Latit.	Diff. of		Differ. of	
		Mile	North.	Merid.		Long.	
			D. M	H. D	D.	M.	
<i>Antwerp</i>	East.	248	51 10	0 17	4.	15	E
<i>Amsterdam</i>	E b N.	266	52 21	0 19	4.	45	E
<i>Alexandria, Egypt</i>	S E b E.	2169	31 7	2 12	33.	0	E
<i>Babylon</i>	E S E.	2724	34 30	3 14	48.	30	E
<i>Callis in France</i>	E b S.	86	50 57	0 47	1.	45	E
<i>Dantzick in Poland</i>	E N E.	961	54 22	1 16	19.	0	E
<i>Dublin in Ireland</i>	N W b W.	296	53 12	0 28	7.	0	W
<i>Edinburgh, Scotland</i>	North	328	55 57	0 0	0.	0	
<i>Florence</i>	S E.	202	43 41	0 47	11.	45	E
<i>Frankfort</i>	East	448	50 4	0 33	8.	45	E
<i>Hamburg</i>	E N E.	538	53 41	0 42	10.	30	E
<i>Lisbon in Portugal</i>	S S W.	985	38 50	0 42	10.	30	W
<i>Mexico</i>	W b S.	6844	20 6	6 49	102.	10	W
<i>Naples</i>	S E b E.	1051	41 51	3 1	3	15.	45 E
<i>Paris in France</i>	S S E.	215	48 50	0 9	2.	15	E
<i>Prague in Bohemia</i>	East	700	50 40	0 58	14.	30	E
<i>Rome</i>	S E b E.	887	41 51	0 52	13.	0	E
<i>Toledo in Spain</i>	S b W.	934	39 46	0 14	3.	30	W
<i>Sevil in Spain</i>	S b W.	956	37 36	0 26	6.	30	W
<i>Venice</i>	E S E.	744	45 18	0 50	12.	30	E
<i>York</i>	North	150	54 0	0 0	0	0	



To find the Sun's Meridian Altitude or Zenith Distance;
(consequently the Latitude at Sea, with the Sun's De-
clination given) with Two Sticks only, (if you are de-
priv'd of your Fore-staff or Quadrant.)

TAKE Two strait Sticks, of any convenient Length,



as O B and C D; let One, as C D, be about $\frac{3}{4}$ the Length of the other: divide O B into any Number of Equal Parts, as suppose 30 Parts; and each of these you may again subdivide into Ten equal Parts. Divide likewise the $\frac{3}{4}$ of C D, into any Number of the like Equal Parts, as suppose 10; then placing the the Stick C D,

(with a Mortice or the like, in the Middle thereof, to move upon O B at Right Angles :) And then, if you would find the Sun's Noon Altitude, a little before 12 at Noon, take the Stick O B, and placing it to your Eye, looking to the Center of the Sun, move the Cross-Stick C D, nearer or farther from your Eye, till you cut the Center of the Sun with the upper Part, D, and the Horizon H O, with the lower Part, C: Then, when the Sun is in the Meridian, admit you have 20 Parts of the Staff from O to B; and the half Length of the Cross-Stick C B or B D, 10 Parts; we may then find the Hypo O C = O D, and Angle C O B, the Half of the Sun's Altitude; by the same Method, as Case 6th, Method 4. of Plain-Sailing, i. e.

$$20 \times 20 = 400 \text{ and } 10 \times 10 = 100.$$

$$\sqrt{400 + 100} = \sqrt{500} = 22.3, \text{ and } OC = 22.3 + \frac{1}{2} OB = 32.3 \text{ Z.}$$

$$\text{As } OC + \text{half } OB \therefore BC :: 86 \therefore \text{Angle } COB, \\ 32.3 \quad 10 \quad 86 \quad 26^{\circ}. 36'. \text{ which} \\ \text{Doubled is } 53^{\circ}. 12'. \text{ the Sun's Merid. Altitude requir'd.}$$

Lastly,

To find the Sun's greatest Declination.

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Lastly, $90^{\circ}.00' - 53^{\circ}.12' = 36^{\circ}.38'$. Sun's Zenith Diff.
The Latitude may be found by the foregoing Rules of working an Observation.

(N^o. 28.) To find the Sun's greatest Declination.

R U L E.

Observe the Sun's greatest and least Meridian Altitude, on the Longest and Shortest Days of the Year; Half the Difference of these Altitudes, is the greatest Declination of the Sun.

Example.

SUPPOSE at London, Anno 1732.

On $\left\{ \begin{array}{l} \text{June} \\ \text{Decemb.} \end{array} \right\}$ the $\left\{ \begin{array}{l} 11^{\text{th.}} \\ 11^{\text{th.}} \end{array} \right\}$ the $\odot$'s Merid. Alt. is $\left\{ \begin{array}{l} 61^{\circ}.58' \\ 14^{\circ}.58' \end{array} \right.$

Their Diff. is the Dist. of the Tropicks $47:00$

The Half whereof is the $\odot$'s greatest Declination $23:30$

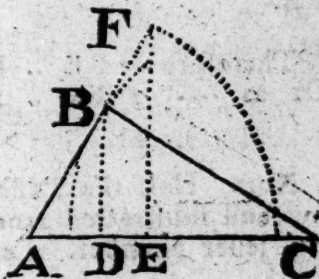
The Three Propositions or Theorems in Plain Trigonometry, (P. 24 and 25.) demonstrated.

THEOREM or PROP. I.

In all Plain Triangles, the Sides are Proportional to the Sines of their Opposite Angles, & *contra*.

Construction.

Produce the lesser Side A B, to F; make A F = to B C, and let fall the Perpendiculars F E, B D, upon the Side A C, produc'd if need be.



Demonstration.

Then will F E be the Sine of the Angle at A, and B D the Sine of the Angle at C, to the Radius B C = A F. Now

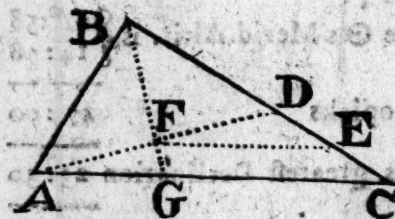
356 *Axioms of Plain Trigonometry demonstrated.*

the Triangles ABD , ABE , are Similar and Proportional (by *Euclid*. 4. 6.) Therefore, as $AF = BC \therefore BD$, $\therefore$ So is the Sine of the Angle A , to the Sine of the Angle C . Q. E. D.

THEOREM II.

IN all Plain Triangles, as the Sum of any Two Sides is to their Difference; so is the Tangent of Half the Sum of their Opposite Angles, to the Tangent of Half their Difference; or of an Arch, which added to the Half Sum gives the Greater, or subtracted, gives the Lesser of the Two Angles requir'd.

Construction.



In the Triangle ABC , make $BD = BA$, and draw the Line AD .

Let fall the Perpendicular BF , upon the Line AD , which will Bisect AD in F ; also draw FE parallel to AC , which will Bisect DC , the Difference of the Two lesser Sides in E .

Demonstration.

The Angle BAF is Half the Sum of the Angles BAC ; and C , and FAG , half their Difference.--- Now if AF be made the Radius of a Circle, BF will be the Tangent of Half the Sum, and FG of the Half Difference. Now the Triangle BGC , is cut proportionably by the Line FE .

Therefore --- $BE \therefore EC \therefore BF \therefore FG$ } Q. E. D.
Or as --- $2 BE \therefore 2 EC \therefore BF \therefore FG$

Note, Half the Difference of any Two Numbers, added to, and subtracted from their Half Sum, gives the greater and lesser Number. Let the Numbers be 12 and 8.

Now

Now $12 + 8 = 20$

And $12 - 8 = 4 = \frac{2}{1} = 10. \frac{1}{2} Z.$ } and $10 + 2 = 12$
 $\frac{4}{2} = 2. \frac{1}{2} X.$ } $10 - 2 = 8$

The { greater } Number; and consequently, the Half Diff.
 { lesser } added to, or subtracted from the Half
 Sum of the Angles, gives the greater or lesser Angle re-
 quir'd.

THEOREM III.

IN all Plain Triangles, as the Base (or Longest Side) is to the Sum of the other Two Sides; so is the Difference of those Sides, to the Segments of the Base, (made by a Perpendicular let fall from the greater Angle of the said Base.)

Construction.

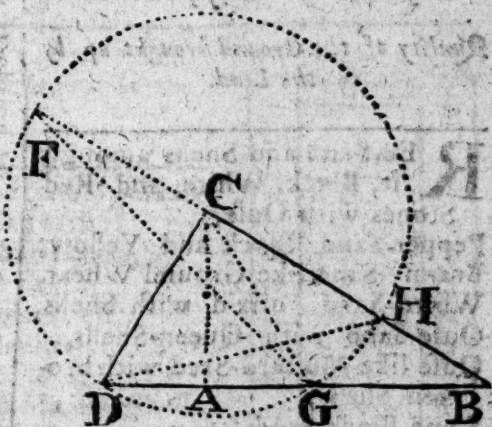
In the Triangle DBD, with the Radius CD, describe the Circle DFH.

Extend, or produce BC to F, and join FG, DH, and CG.

Let fall the Perpendicular CA.

Demonstration.

Then is BF = Sum of the Sides, CD and CB; and HB is = their difference; also GB is the Difference between AB and AD; the Segments of DB the Base: And the Triangles HDB and BFG, are Similar, (or like) because of their Equal Angles, D and F; and the Arch GH being the double Measure of them both: Also the Angle at B, common to both the Triangles, HDB and BGF. Therefore,



Proportionably ;

As $BD \dots BE :: HB \dots GB$.

That is, as DB the Base, is to FB , the Sum of the Sides,
is HB the difference the Sides CB and CD , to GB , the
difference of the Segments of the Base. *Q. E. D.*

Then the Half $GB \pm \begin{matrix} BD = AB \\ BD = AD \end{matrix} \}$ The Base of the

Right Angled Triangle $\begin{cases} BAC. \\ DAC. \end{cases}$



(N^o. 29.) *A Table of the Soundings coming into the
British Channel; the Quality of the Ground brought
up by the Tallow on the Lead; with the Bearings and
Distance of Silly, the Lizard, &c.*

*Quality of the Ground brought up by
the Lead.*

	Depth.	Bearings	Dist.	Latit.	
		Silly.		D.	M.
R ed Sand and Shells amongst it, Black, White, and Red Stones with Ouse,	77	<i>NNW.</i>	33	48	52
Pepper-Sand, Black and Yellow,	72	<i>E b N.</i>	25	49	50
Branny Sand, like Ground Wheat,	72	<i>E b N.</i>	15	48	50
White Sand, mix'd with Shells,	50	<i>Sou. b.</i>	5	50	20
Ouse Sand with Queen-Shells,	45	<i>SSE.</i>	5	50	12
Ouse like Mustard-Seed with bro- ken Shells,	58	<i>E b S.</i>	8	50	12
Some Black Sand,	72	<i>E b N.</i>	7	49	15
Rocky Ground,	60	<i>ENE.</i>	7	49	15
Sand and Ouse together,	80	<i>ENE.</i>	20	49	15
White and Red Sand mix'd, with Shells,	85	<i>NE b E.</i>	22	49	10
White Sand, with Ouse and Nits,	55	<i>NE b E.</i>	10	49	20
Branny Sand, with White and Red Shells,	100	<i>NE b E.</i>	50	49	50
Black Sand,	64	<i>NE b E.</i>	25	49	50
Branny Sand, with some Pieces of Shells,	48	<i>NE b E.</i>	6	49	10
Branny Sand, Herring-Bones,	65	<i>NE b E.</i>	13	49	43
Small Stones,	65	<i>NE.</i>	10	49	40

Quality

Soundings coming into the Chamel.

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Quality of the Ground brought up by the Lead.

	Depth	Bearings	Dif	Latit.	
		Silly.		D.	M.
Small Red Sand,	57	N. E. b N.	10	49	20
Broken Shells, with White and Red Sand,	65	North.	12	49	15
White Sand on the East Part of the Bank,	65	North.	10	49	47
Branny Sand, with Black and broken Shells,	50	N. W.	4	50	10
Stony Ground,	60	N W.	7	9	47
Red and Black Sand, with glistering Shells,	61	N W. b. N.	2	50	25
Fine white Sand, with a little Ouse,	63	W. b. N.	13	50	25
Red and Black Sand, with glistering Shells,	66	West.	21	50	8
Fine White Sand, with glistering Shells,	75	W. b. S.	31	49	50

Quality of the Ground brought up by the Lead.

	Depth	Bearings	Dif
		Lizard.	
Marlhy Shells, and some Scollop-shells,	48	N E.	6 ¹ / ₂
Marlhy Shells and Hakes-Teeth,	53	NE b. N.	10
Marlhy Shells, like Oatmeal-Husks,	50	N N E.	9
Marlhy Shells and Hakes-Teeth,	58	N b E.	15
Stones as big as Beans, so 4 l. off,	39	North.	1
Grey Sand, like Oatmeal-Flower,	45	N W.	5
Marlhy Shells and small Stones,	43	N W.	3
Small Slingly Stones, and Marlhy Shells,	47	W N W.	3 ¹ / ₂
Fine Marlhy Shells and white Stones,	40	W b. N.	4
Black gravelly Ground with small Stones,	41	W b. S.	30
Scollop-Shells,	57	NE b. E.	12
Great Stones and rough Ground,	44	NE b. E.	4
		Eddy Stone	
Dirty Brown Sand and Hakes-Teeth,	35	North.	¹ / ₂
Dirty Brown Sand,	34	West.	2
Fine Sand, and within this 28 and 30 Fath.	26	South.	1

Quality of the Ground brought up by the
Lead.

	Depth.	Bearings	
		Start.	Diff.
{ Like the Dust of a Grindstone, with Flakes, Teeth and Shells, Gravelly Sand, small Stones, and Shells, Reddish Shells mash'd, as if beaten in a Mortar, white Sand and Scollop-shells,	40	NE b E. Nly	8 $\frac{1}{2}$
	43	NW b W.	4 $\frac{1}{2}$
	38	NW b N.	3
	38	NbW. Wly	12
	42	NW b W.	14
Small shingly Stones, as big as Pease, Streamy Ground, with small Stones, The same, with some black Sands, Fine Sand, with Scollop-shells, Fine Sand, Scollop-shells, and small Stones, Shingly Ground, Small Stones,		Portland.	
	33	NE b E.	8
	40	North.	8
	33	N b E.	5 $\frac{1}{2}$
	41	NE b N.	11
	40	NNE.	8
	27	NE b E.	2 $\frac{1}{2}$
	20	WNW.	2 $\frac{1}{2}$
Great shingly Ground, Small shingly Ground, Rocky Ground,		Needles.	
	17	NE b E.	2
	19	NE $\frac{1}{2}$ E.	2 $\frac{1}{2}$
	13	N. E.	2
{ All the Ground from the Albions, to to the East End of the Wight, is Chalky and brown Sand,		Idle Wight.	
	20	N. b W.	3 $\frac{1}{2}$
	21	E b N.	4
	18	N b E.	3
Rough Ground, with some big Stones, A kind of Sandy Fishing-Ground, Fishing-Ground, somewhat Red with Stones as big as Pease, and some as big as Beans,		Dunwose.	
	16	W b S.	4
	21	West.	4
	33	WNW.	8
	26	N b W.	6

APPEN-

APPENDIX.

A Collection of sundry Pleasant and
Critical Questions in NAVIGATION;
design'd for the Improvement and Diversion
of the Learner, at his spare Hours.

In Plain-Sailing.

QUESTION I.

Admit a Ship sails from
a certain Port, between
the South and West, and
finds the Distance Run and
 $\times$ s. Lat. in one Sum 160 m.
and her Departure 60 m.
What's her Course, Dist. and
 $\times$ s. Lat. severally?

Course steer'd, with her Di-
stance and Departure?

QUEST. III. Admit a Ship
sails from a Port in the S. W.
Quarter of the Compass 120
m. until the Sum of her $\times$.
Lat. and Departure be 160 m.
What Course hath she steer'd,
and what Southing and West-
ing hath she made?

QUEST. II. Suppose a
Ship sails from the Tropick
of Cancer between the South
and East, and finds her Lat.
by Observation to be $12^{\circ} 24'$.
N. and her Distance and De-
parture together is 666
Leagues: I demand the

QUEST. IV. Suppose a Ship
sails from the Lat. of $5^{\circ} 00'$.
S.N.E. by N. till her Distance,
 $\times$. Lat. and Departure, in one
Sum is 600 Leagues: I de-
mand

mand them severally, with the Lat. arrived into ? the Course steer'd, and Lat. arriv'd in ?

QUEST. V. If a Ship sails S.W.b.S. from the Lat. of $46^{\circ} 27'$ N. until her Distance is 160 Miles more than her α 's. Lat. I demand them severally?

QUEST. VI. If a Ship sails North-Easterly 600 m. and then her Departure is 120 m. more than her α . Lat. What's her True Course, α . Lat. and Departure?

QUEST. VII. Suppose a Ship sails W S. W. from the Lat. of $40^{\circ} 20'$ N. and then finds her Distance to be 90 m. more than her Departure : I demand the wanting Particulars ?

QUEST. VIII. Admit a Ship sails from the Lizard in the S.W. Quarter, 153 m. then finds her α 's. Lat. to exceed her Departure by 30 m. I demand her direct Course, Departure, and Lat. come into ?

QUEST. IX. Suppose a Ship sails from the Lat. of $5^{\circ} 55'$ North, between the South and East, (but more Southerly than Easterly) till her Distance, α . Lat. and Departure, together was 600 m. I demand them severally, with

QUEST. X. If a Ship sails South westerly, until her Distance is 200 m. more than the α . Lat. and the α . Lat. is 96 more than her Departure : I demand them severally, with the direct Course steer'd?

QUEST. XI. Suppose a Ship sails from the Equator, between the North and East, and for every 50 Leagues she runs, she differs her Lat. 40 L. and thus she continued her sailing, till her Departure was 80 L. I demand the Ship's direct Course, and Distance, and Lat. she is come into ?

QUEST. XII. Admit a Ship sails from the Lat. $3^{\circ} 33'$ S. between the South and West ; and for every 7 Leagues she runs, she departs from the Meridian 4 Leagues ; and so she continues, till she arrives in the Lat. of $17^{\circ} 39'$. I demand her direct Course, Distance and Departure ?

QUEST. XIII. Admit a Ship sails from a Port, in the Lat. 20° North, between the South and East, and for every 3 Miles she differs in Lat. she departs from the Meridian 4 Miles ; and thus she continues, till her Distance run is 555 Leagues. I demand

mand the wanting Particu-
lars ?

QUEST. XIV. Admit a Ship sails from a Port, in Lat. $22^{\circ} 55'$ North, between the South and West, till her Distance is 142 Leagues more than her Departure, and 145 Leagues more than her $\angle$ Lat. I demand her Distance, Departure, Course, and Lat. come into ?

QUEST. XV. A Master of a Ship, sailing towards the East, hath forgot his Course; yet thus much he knows, that if he had sail'd upon his true Course 108 Leagues, he should have rais'd the Pole $2^{\circ} 51'$, and have been as much more distant from the Meridian than now he is; and also should have been 57 m. more Northerly. I demand the Course, Distance and Departure ?

QUEST. XVI. Admit a Ship sails from an Island, in Lat. 4° South, N. E. b. N. until she comes into the Lat. 4° North. I demand her Distance and Departure to and from the Equator ?

QUEST. XVII. Suppose Two Ships sail from the Tropick of Cancer, the first S. W. and the other S. E. the first Ship sail'd 665 Leagues, and

the other sail'd to the Equator. I demand the Rest ?

QUEST. XVIII. Admit four Ships sail from one Port on the Equator. The First steer'd N. W. the Second N. E. till they came to the Tropick of Cancer: The Third sail'd S. E. and the Fourth S. W. till they arriv'd at the Tropick of Capricorn, and were then asunder 940 Leagues. I demand each Ship's Distance and Departure ?

QUEST. XIX. Suppose a Master of a Ship, coming to an Anchor, and would Moore his Ship, having 95 Fathom to his small Bower Cable's Service; and found 35 Fathom of Water, the Buoy bearing up and down. I demand how much Best Bower Cable he must veer out, to bring his Small Bower Service in the Hawse, when the Ship is hove up again and Moor'd ?

QUEST. XX. Suppose that Three Ships are all bound to one Port; One Ship is in the Lat. of 20° North, the Second in Lat. 30° North, and the Third in Lat. 40° North; the Port lies in the Lat. of 50° N. and they all sail'd one Distance, viz. 740 Leagues. I demand their several Courses and Departures ?

QUEST. XXI

QUEST. XXI. There were Three Flags set Sail, in the *Albemarle*, *Union* and *Namur*, from Port Mahon, in Lat. $39^{\circ} 55'$ North; with four Ships of War more, viz. the *Cornwall*, *Orford*, *Revenge* and *Torbay*: The *Albemarle* sail'd N. the *Union* sail'd N E b E. and *Namur* East, each 85 Leagues. The *Cornwall* sail'd N E b N. until she made a Tangent with the *Albemarle*; and the *Orford* sail'd also N E b N. until she made a Tangent with the *Namur*; and the *Torbay* sail'd North, the *Revenge* East, until they made Sines with the *Union*. Now I demand each Ship's Distance, $\times$ Lat. and Departure; the Flags being the Radius?

QUEST. XXII. Two Ships sail from an Island in the Latitude of $30^{\circ} 59'$ North, and they are bound to the Eastward. In their sailing they make an Angle of $112^{\circ} 30'$, and one comes into the Lat. of 29° North, and then both are under one Meridian. I demand each Ship's Distance and Departure?

QUEST. XXIII. There are Two Ports, A and C, both in the Lat. of 45° North: A Ship at the Westernmost at A, sails betwixt the North and East to another Port at B, 45 Miles; and then, altering her Course 90° , or 8 Points, sails

a certain distance between the South and East, and arrives at the other Port, C; and her Departure or Easting from the second Port, B, to the third Port, C, is 48 m. I demand what was the Ship's Easting from the first Port, A, to the Port B; and what Lat. the Port B lies in: Also, her Course and Distance from the second Port at B, to the third Port at C?

QUEST. XXIV. Suppose a Ship set sail from a Port at K, in the Lat. of 44° North: She runs a certain distance between the North and West, and then arrives at another Port at C, in the Lat. of $44^{\circ} 18'$ North; from the Port C, she alters her Course 90° and sails between the South and West a certain distance, which exceeds her former distance sailed, by $7\frac{1}{2}$ m. and then arrives at another Port, A, in the same Lat. with the Port sailed from B. I demand the distance asunder of the First and Third Ports, B and A: Also the distance of the Ports A and C, and C and B; with the First and Second Courses and Departures, D B and D A?

QUEST. XXV. Admit two Ports, A and B, lie both in the Lat. of 30° North, a Ship sails from A, between the North and East, a certain distance, and then arrives at ano-

another Port, D, in the Lat. of $30^{\circ} 18'$ North; and then altering her Course 90° , sails between the South and East a certain Distance, to another Port, B. I demand her Course, Distance, and Departure from A to D; and her Course, Distance, and Departure from D to B?

QUEST. XXVI. Suppose a Ship sails from a Port at A, between the North and East, to a Port C, in the Lat. of 50° North, and then the Sum of her Distance and Departure is 54 L. from the Port C; she alters her Course, 90° , and sails in the South-East Quarter of the Compass, and arrives at another Port, B, in the same Latitude with the Port A, and finds her Second Distance, Run and Departure, in one Sum 35, 7 L. I demand her Course, Distance, and Departure from A to C, and from C to B; and the Latitude of the Ports A and B, and their Distance asunder?

QUEST. XXVII. There are Three Islands, A B and C, in Form of a Right Angled Triangle; that is, the Island B, bears of C due South; A bears from B, due West; and suppose a Ship sails from C to A, between the South and West, and that the Sum of her Distance, $\propto$ Lat. and Departure, is found to be 90 L. and the Area or Content of this Right Angled Triangle

the Ship hath made, is 330 L. I demand her Course, Distance, $\propto$ Lat. and Departure severally? Or, which is the same, the Distance of each Island from each other?

QUEST. XXVIII. A Ship sails between the South and West, till the Sum of her $\propto$ Lat. and Departure is 70 m. and the Sum of her Distance Run and Area of the Triangle is 650 m. (or the Difference of the Area and Distance is 550 m.) I demand the Distance, Difference, Lat. and Course steer'd?

QUEST. XXIX. There is a Round Sea or Lake, of an unknown Diameter, upon which the Wind is observ'd to blow always one Way, but upon what Point of the Compass is unknown: Upon the Coast hereof are Two Ports, A and B, diametrically opposite to each other; so situate, that the Trade-Wind blowing there, will be somewhere upon the Larboard Quarter, during their sailing from A to B; but how many Points a-baft the Beam, is unknown; the Course and Distance between the Two Ports, is also unknown. — A Ship at A intending for B, was no sooner got out of the Harbour, but he was assaulted by Pirates; who, after a long Conflict, carried away his Main-Mast, Mizzen-Mast, Fore-

Fore-Top-Mast, and also his Rudder; and came A-board to Plunder, taking away his Goods, Books, Instruments, Charts, Compasses, &c. Being left in this Distress, he sets his Fore-sail, and having no Rudder, nor any more Sail to command her with, he let her drive right before the Wind, till at last she drove a-shore in a little Creek, altogether unknown to the Master; nor did he know the Course and Distance from this Creek, either to the Port sailed from, or to the Port bound for: However, here he got such Masts and Sails as he had occasion for, with a Rudder, and all that was necessary to the Working of the Ship; but could get no Books, Charts, Instruments or Compass. I demand what Means he must use, to guide the Ship to the Port at B?

QUEST. XXX. There is a Round Lake, whose Diameter

is 360 m. upon the Coast of which lie Two Ports, A and B, whose nearest Distance in a strait Line, is 120 m. but their Bearing or Situation is not known: A Ship at A, sails away West, a certain Distance, and then arrives at another Port at O, whose Bearing and Distance both from A and B, are unknown; and at the Port at O, he takes in Goods for B. I demand what Course he must steer, to find the Port at B?

QUEST. XXXI. Two Ships of War, the *Suffolk* and *Kent*, sail'd from *Flores* in Lat. $39^{\circ} 39'$ North, 5 Points afunder: The *Suffok* sail'd between the North and West, and made her Departure 88 m. and the *Kent* sail'd North-Easterly, and made her Departure 60 m. and then they were both in one Lat. I demand their Courses, Distances, and Latitudes?

In Oblique Plain-Sailing.

QUESTION I.

I Being in a Ship, bound to an Island, and know neither the Course, Distance, $\propto$ Lat. nor Departure; but I heard the Master tell the Mate, that if he would sail N. W. b. N.

92 Leagues, then the Island would bear South, Distance 180 Leagues. The Course and Distance of the Island, at first setting out is requir'd.

QUEST. II. Suppose a Merchant Ship in the Lat. $45^{\circ} 30'$ North,

North, falls into the Hands of Pirates, who take away his Sea-Compass; after which, he sails as directly as he can 67 Leagues between the South and West; and at the End of Two Days meets a Ship of War, who also had been the Day before in the Lat. $45^{\circ} 30'$ North, and had sailed thence, S.E. 6 S. 39 Leagues; now the Merchant-Ship left those Pirates to and fro, where they robb'd him; and the Man of War being desirous to speak with those Pirates, I demand what Course he must shape to meet them?

QUEST. III. Coasting along Shoar, I saw Two Capes of Land; the First did bear N. the Second did bear W.N.W. Then I stood away N.W.b.N. 9 m. until the First did bear from me E.b.S. and the Second S.b.E. The Bearing and Distance of them is requir'd?

QUEST. IV. Suppose a Ship sailing N.W. Two Islands appear in sight, one bears W.N.W. the other N. of the Ship; and when the Ship had sail'd 6 m. farther, the first bears W.b.S. and the other N.E. their Bearing and Distance is requir'd?

QUEST. V. Three Ships sail from one Port; the First sails S. W. b. W. the Second, W. b. S. $\frac{1}{2}$ W. and the Third,

N.W.b.W. 8 Miles. Then the First bears from the Third, S.b.W. the Second bears from the Third S. S. E. The First and Second Ship's Distance sail'd, and their Bearing and Distance from each other is requir'd?

QUEST. VI. Admit sailing along Shore, I see two Head-Lands, the Eastermost bears N. N. E. and the Westermost N. W. from me; at the same time, an Island bears South: Then, after I sail'd West 8 m. the First did bear N.E.b.E. $\frac{1}{2}$ E. the Second N.N.E. and the Island E. S. E. from me. The Bearing and Distance of these Places from each other is requir'd?

QUEST. VII. A Fleet of Ships, with Four Men of War, with the Wind at W.b.S. sails away S. E. 3 Miles an Hour, till hearing of some Pirates to the Northward of them, the Commadore sends out a Man of War a-Cruising, who sails due North 7 Miles an Hour, for the space of 11 Hours; and finding the Pirate, (after an Hour's Conflict) took him; the Fleet all the while sailing S. E. 3 Miles an Hour. Now I demand what Course the Man of War and the Pirate must sail, that they may just fall in with the Fleet. without altering their Course; supposing they sail 7 Miles an Hour?

QUEST.

QUEST. VIII. Coasting along Shore, I set Two Head Lands; one bears N. b. W. the other N. E. b. E. and a Buoy bears N. E. b. N. At the same time I saw Two Islands; the one bears S. S. W. $\frac{1}{2}$ W. and the other E. S. E. and a Rock S. E. Then I sailed East 100 Miles, and the first Head-Land bore N. W. b. W. the second N. $\frac{1}{2}$ E. and the Buoy N. W. $\frac{1}{2}$ W. then the first Island bears W. S. W. and the other Island, S. b. E. $\frac{1}{4}$ E. and the Rock S. W. b. W. I demand their Bearing and Distance from each other?

QUEST. IX. Two Men of War, the *Breda* and *Ruby*, sail'd in search of Pirates, and took their Departure from the *Grand Canary* in Lat. 28° . N. both sailing one Course, South-Westerly 69 m. and came up with the Pirates, and engag'd them, viz. Three Pirates, Two of which were taken by the *Breda*; and the Third ran away, and was pursued by the *Ruby* on the same Course, until her Departure from the *Grand Canary* was 77 Miles, and then took the Third Pirate. Now I demand the *Ruby's* Course, to join with the *Breda* again, and her Distance from the *Grand Canary*; and also in what Lat. she took the Pirate?

QUEST. X. Suppose the Wind at South, and a Ship of

War in sight of a Head-Land, bearing N. E. 7 Leagues, was ordered by the Commadore to Weather it, so as to reach an Island 3 Leagues to Windward of the said Head-Land, at Two Boards, having the n her Starboard Tacks Aboard; and can make her Way good within 6 Points of the Wind. I demand how far she must run upon that Tack, before she goes about; with her Larboard Tacks, to bring the Head-Land 3 Leagues to Leeward?

QUEST. XI. Two Ships sail from one Port; the First Ship sails due South, and the other W. S. W. more than the First 35 Leagues; and then they were 76 Leagues asunder. I demand how many Leagues each Ship had then sailed?

QUEST. XII. Two Ships sail'd from one Port; the first Ship sail'd S. S. W. a certain distance; then altering her Course, she sail'd due West 92 Leagues: The second Ship sailed 120 Leagues, and meets with the First. I demand the second Ship's Course, and how many Leagues the first Ship sailed upon the S. S. W. Course?

QUEST. XIII. Two Ships sail from two several Ports in one Latitude, and 90 Leagues asunder; the westernmost Ship sails N. E. b. E. the Easternmost Ship

Ship sails upon some Point between the N. and W. and then they meet. If the Distance Run, of both these Ships be together 136 L. I demand them severally, and the Eastermost Ship's Course?

QUEST. XIV. A Ship at an Island, in the Lat. 47° . $56'$. N. sails to another Island W.S.W. then to a Port N.b.E. until the first Island bears from her E. S. E. Now her Dist. sailed on both Courses, with her Dist. to the first Island together, is 342 m. I demand her Dist. sailed on each Course, with her Dist. from the first Island?

QUEST. XV. Three Ships are at Three Ports; the Eastermost Ship is distant from the Northernmost 75 m. and bears S.E.b.S. and the Westernmost is distant from the Northernmost 85 m. and beareth S.S.W. They are all bound to an Island, that is, at an equal Distance from them. I demand each Ship's Course and Dist. from the said Island?

QUEST. XVI. Admit Two Ships at one and the same Instant of Time, had sailed from one Port; the one sails N.W.b.N. 6 L. a Watch, and the other sails N. E. 8 L. in a Watch; and they arriv'd at Two several Ports at one and the same Time, the Ports being 158 L. asunder. I demand

each Ship's Distance sail'd, the Bearing of these Two Ports, and the Time they were sailing to them?

QUEST. XVII. Admit a Ship sails from the *Pice of Eyah*, first N.b.E. $\frac{1}{2}$ E. then N.W. $\frac{1}{4}$ W. then S. and so return'd again to *Eyah*; having sailed in all 158 L. I demand how many Leagues she sailed upon each Course?

QUEST. XVIII. Two Ships in the same Lat. Dist. 600 m. the first sails N. Easterly, the second sails N. Westerly, and they meet; and at their meeting they make an Angle of 102° . $10'$. and the first Ship had sailed 162 m. more than the other. I demand each Ship's Course and Distance?

QUEST. XIX. Admit Two Ships sail from one Port; one sails N. N. W. the other sails N.W.b.W. to two Islands, bearing off one another N.E.b.E. and S.W.b.W. Dist. 80 L. I demand the Dist. each Ship must sail to these Islands?

QUEST. XX. Suppose a Ship sails N. a certain Dist. then E.N.E. 80 m. and S.E. a certain Dist. lastly, S.W.b.S. 160 m. and then is found in the first Place she sailed from. I demand how many Miles she sailed N., and S. E.?

H R

QUEST.

QUEST. XXI. Admit a Ship at D, to spy Three Head-Lands A, B, C; from A to B is 70 L. from B to C is 60 L. from C to A, is 50 Leagues: C bears from the Ship N. A. N. b. E. E. and B, N. N. E. I demand the Dist. the Ship was from these three Head-Lands, A, B and C, and the Bearings of each from one another?

ANSW. The Dist. from the Ship to each Head-Land is 100 Leagues.

QUEST. XXII. Admit I see Sixteen Islands, each be-

ing 9 m. distant from me; and the First did bear off me E. the second E. N. E. the Third N. E. the Fourth N. N. E. the Fifth N. the Sixth N. W. the Seventh N. W. the Eighth W. N. W. the Ninth W. the Tenth W. S. W. the Eleventh S. W. the Twelfth S. S. W. the Thirteenth S. the Fourteenth S. S. E. the Fifteenth S. E. the Sixteenth E. S. E. The Bearings and Distance of these Islands asunder is requir'd?

ANSW. The Dist. from the Ship to each Island is 100 Leagues.

QUESTION XXIII. Three Ships sail'd from a certain Port to Sea; The other Ports whose Latitude agree: Fifty five Leagues the first sail'd, South his Coast; To other to Coasts unknown, 'twixt South and West; Till each arriv'd in his true diff'rent Place; And they asunder Leagues Fifty seven just was; Angle 38° made; whence they begun. Pray tell me what's the Course and Distance Run?

ANSW. The Course is S. by E. and the Distance is 100 Leagues.

QUESTION XXIV. From Edystone, viewing the Neighb'ring Shore,

And willing to know how far it is o'er,
To Three Ports within sight; their Distances are known
From each other, as here under I've shewn:
I thought the best I could do was to try,
Which way from the Rock those Three Places lie.
This I have done, and it is noted here:
Pray what will the Three Distances appear?

The Dist. from $\left\{ \begin{array}{l} \text{Plymouth to Lizard, 60} \\ \text{Lizard to Start Point, 70} \\ \text{Start Point to Plymouth, 20} \end{array} \right\}$ Miles.

$\left\{ \begin{array}{l} \text{Plymouth} \\ \text{Lizard} \\ \text{Start Point} \end{array} \right\}$ bears from Edystone Rock $\left\{ \begin{array}{l} \text{North} \\ \text{W. S. W.} \\ \text{E. b. N.} \end{array} \right\}$

Questions in Navigation. 371

In Traverse,

Various Questions, of Diverse Figures: of a House, Church, Fort, Anchor, Castle, True Lovers Knot, &c. Ornamental to the Learner's Book.

QUESTION I.

A Ship bound to Chuse from an Island in the Lat. of $26^{\circ} 10'$ N. steers away these several Courses, viz. N. 40 m. N. E. 50 m. S. E. 50 m. N. 70 m. E. 12 m. S. 70 m. What Lat. is she come into, N. E. 50 m. S. E. 50 m. I demand her Departure, Distance, and Dist. made from the Island?

QUEST. II. A Ship meeting with contrary Winds, sails as follows, viz. N. 40 m. N. N. E. 10 m. E. S. E. 50 m. N. b. E. 60 m. S. b. E. 60 m. N. b. E. 80 m. S. b. E. 80 m. N. b. E. 100 m. S. b. E. 100 m. N. b. E. 80 m. S. b. E. 80 m. N. b. E. 60 m. S. b. E. 60 m. I demand the rest?

QUEST. III. A Ship sails these Courses, viz. N. 150 m. E. 20 m. S. 15 m. N. 10 m. N. b. E. 60 m. S. b. E. 60 m. S. 30 m. E. 15 m. S. 15 m. E. 20 m. N. 15 m. S. 20 m. I demand, &c.

QUEST. IV. Admit a Ship in Lat. $47^{\circ} 15'$ N. is forced by contrary Winds to sail as follows, viz. S. W. 12 m. N. 50 m. S. W. 6 m. N. W. 7 m.

H h 2

E. N.

N.E. 7m. S.E. 6m. N.E. 50m.
 N.W. 14m. S.W. 50m. S.E. 6m.
 S.W. 7m. N.W. 7m. N.E. 6m.
 N.W. 50m. S.W. 14m. S.E. 50m.
 N.E. 6m. S.E. 7m. S.W. 7m.
 N.W. 6m. S.W. 50m. S.E. 14m.
 N.E. 50m. N.W. 6m. N.E. 7m.
 I demand the Lat. come into,

QUEST. VI. A Ship from

the Lat. $49^{\circ} 30'$. S. sails as follows, viz. N.E. 89m. W. 30m. S.E. 59m. N. 30m. S.W. 59m. E. 30m. N. W. 59m. S. 30m. N.E. 59m. W. 30m. S.E. 59m. N. 30m. S.W. 59m. E. 30m. and N. W. 59m. I demand, &c.?

QUEST. VII. A Ship in

the Lat. of 50° N. sails as follows, viz. E. 20m. S. 20m. W. 10m. S. half W. 115m. E. 8m. S. 8m. W. 3m. S. 16m. S. b. W. half W. 23m. N. b. W. 23m. N. 16m. W. 8m. N. 8m. E. 8m. N. half W. 115m. W. 10m. N. 20m. E. 20m. I demand, &c.?

QUEST. IX. A Ship meet-

ing with contrary winds, sails from the Lat. of 40° N. viz. W. b. S. 45° 31m. E. b. S. 8m. W. b. S. 10m. S. E. 45° 31m. E. b. S. 25m. E. 35m. E. S. E. half S. 30m. N. W. half N. 10m. E. 45° 31m. S. E. b. E. 30m. N. W. b. N. 25m. N. E. b. E. 20m. W. S. W. 45° 31m. W. half N. 70m. S. E. b. S. 20m. N. W. b. W. 98m. N. E. b. E. 28m. S. W. b. S. 10m. W. half S. 21m. I demand the rest?

QUEST. X. Sailing from the Lat. of $51^{\circ} 32'$ N. and meeting with contrary Winds, am constrain'd to sail, viz. S.W. 52m. S.S.W. 14m. S.S.E. 14m. S.E. b. E. 14m. E. 14m. N. N.E. 45° 31m. E. 24m. S.S.E. 45° 31m. E. 24m. E. 14m. N.E. b. E. 14m. N. N.E. 14m. N. N.W. 14m. N. W. 52m. S. 78m. N. W. 7m. S. b. E. 45° 31m. E. 19m. N. b. E. 45° 31m. S. W. 7m. I demand the rest?

QUEST. XI. Admit from the

Lat. of 30° N. I sail these Courses, viz. N. 21m. S. E. 85m. N.E. 15m. N.W. 70m. S.W. 30m. S.E. 30m. N.E. 70m. N.W. 15m. S. W. 85m. N. 21m. E. 100m. W. N.W. 34m. S.E. 19m. S.W. 19m. E. N.E. 34m. I demand the rest?

QUEST. XII. Being bound

to Cruise, from an Island in Lat. 39° N. I sail as follows, viz. N. N.E. 32m. N. N.W. 32m. S.S.W. 32m. S.S.E. 32m. E. N.E. 32m. E. S.E. 32m. W. S.W. 32m. W. N.W. 32m. S.S.E. 32m. S.S.W. 32m. N. N.W. 32m. N. N.E. 32m. W. S.W. 32m. W. N.W. 32m. E. N.E. 32m. E. S.E. 32m. S. 60m. N. W. 86m. N. E. 86m. S. E. 86m. S. W. 86m. I demand the Lat. in, Dep. Course and Dist?

QUEST. XIII. Admit a Ship

from the Lat. $32^{\circ} 30'$ N. sails these Courses, viz. S. 10m. W. 10m. S. 30m. E. 30m. S. 15m. W. 30m. S. 30m. W. 15m. N. 30m. W. 30m. N. 15m. E. 30m. N. 30m. W. 10m.

W. 10m. N. 10m. W. 10m. W. 40m. N. 19m. N. W. 22m.
 N. 10m. W. 10m. N. 10m. S. W. 22m. S. 19m. I demand, &c.
 W. 10m. N. 10m. W. 10m. N. 10m. I demand the rest?

QUEST. XIV. Admit a Ship from the Lat. 45° S. sails, viz. S, E, b, E. 18m. S 20m. E 21m. N 10m. E 10m. S 10m. E 21m. N 10m. E 10m. S 10m. E 20m. N 40m. N, W. 20m. S, W. 20m. N 20m. N 20m. W. 20m. N 20m. W 20m. N 20m. W 20m. S 20m. W 20m. S 20m. W 20m. N, W. 20m. S, W. 20m. S 40m. E 20m. N 10m. E 10m. S 10m. E 20m. N 10m. E 10m. S 10m. E 21m. N 20m. N, E, b, E. 18m. I demand, &c.

QUEST. XV. Admit a Ship departs from an Island in Lat. 41° N and sails, viz. N. E. 60m. S, S, W. 113m. N, N, W. 113m. S, E. 120m. W, N, W. 113m. E, N, E. 113m. S, W. 120m. N, N, E. 113m. S, S, E. 113m. N, W. 120m. E, S, E. 113m. W, S, W. 113m. and N, E. 60m. I demand, &c.

QUEST. XVI. Suppose a Ship sails from the Lat. of 30° N these Courses, viz. N 30m. E 12m. N half E 60m. S half E 60m. E 12m. N 92m. E 6m. S 12m. E 6m. N 12m. E 6m. S 12m. E 6m. N 12m. E 6m. S 92m. E 12m. N half E 60m. S half E 60m. E 12m. S 35m.

H b 3

QUEST. XVII. A Ship from Lat. 44° $40'$ N, sails these several Courses, viz. W. 105m. N. 15m. E. 15m. S. 15m. E. 15m. N. 15m. E. 15m. S. 15m. E. 15m. N. 15m. E. 15m. S. 44m. E. 18m. N. 18m. E. 18m. S. 18m. E. 18m. N. 18m. E. 18m. S. 18m. E. 18m. N. 44m. E. 15m. S. 15m. E. 15m. N. 15m. E. 15m. S. 15m. E. 15m. N. 15m. E. 15m. S. 15m. I demand the rest?

QUEST. XVIII. Suppose a Ship from the Lat. 50° $30'$ N, sails, viz. S, W. 48m. N. 34m. E. 84m. S. 34m. N. 48m. S. 34m. E. 34m. N. E. 99m. N. W. 18m. S. W. 18m. S. E. 29m. N. E. 48m. S. 34m. W. 34m. S. b, W. 40m. E. b, N. 40m. N. E. 48m. W. 34m. S. 34m. S. E. 29m. N. E. 18m. N. W. 18m. S. W. 29m. S. 34m. E. 34m. N. W. 48m. W. b, N. 80m. N. W. 48m. E. 34m. S. 34m. S. W. 29m. N. W. 18m. N. E. 18m. S. E. 29m. S. W. 48m. E. 34m. N. 34m. E. b, N. 40m. I demand the rest?

QUEST. XIX. Admit a Ship sails from a Port in the Lat. of 46° $30'$ N, meeting with contrary Winds, sails as follows, viz. N, W, b, N. 40m. E. 15m. N, E. 30m. S. E. 10m. S, W. 10m. N. W. 30m. N. E. 10m.

10m. S, E. 10 m. S, W. 30m. N 112 m. W 28 m. S 112 m.
 N, W. 10m. N, E. 10m. S, E. N, W, b, W. 5° W 47 m. N
 30m. E, 15m. S, W, b, S. 40m. 40 m. E 4 m. N 4 m. W 35 m.
 N, E, b, E. 40m. S, 15 m. S, E. S 4 m. E 4 m. S 40 m. S, W, b,
 30m. S, W. 10m. N, W. 10m. W 5°. W 48 m. N 112 m. W
 N, E. 30m. S, E. 10m. S, W. 29 m. S 112 m. W 30 m. I
 10m. N, W. 30m. N, E. 10m. demand the rest?
 S, E. 10m. S, W. 30m S, 15m.
 N, W, b, W. 40m. S, E, b, S. 40m.
 W, 15m. S, W. 30m. N, W. 10m.
 N, E. 30m. S, E. 30m. S, W. 10m.
 N, W. 10 m. N, E. 30 m. S, E.
 10m. S, W. 10m. N, W. 30m.
 W. 15 m. N, E, b, N. 40 m.
 S, W, b, W. 40m. N. 15m. N, W.
 30m. N, E. 10 m. S, E. 10 m.
 S, W. 30 m. N, W. 10 m. N, E.
 10 m. S, E. 30 m. S, W. 10 m.
 N, W. 10 m. N, E. 30 m. N,
 15m. S, E, b, E. 40m. I de-
 mand the rest?

QUEST. XX. A Ship sails
 from an Island in the Lat. 49°
 10' N. these several Courses,
viz. N 149m. E 60m. S 23m.
 N, E, b, E. 5°. E 23m. S, E, b, E.
 5° E 23m. S 5m. S, E, b, E.
 5°. E 14 m E 13 m N 36 m
 E 10m S 24 m N, E, b, E. 5°
 E 26 m S, E, b, E 5°. E 26 m.
 N 24 m E 12 m S 37 m E.
 16 m N, E, b, E. 5°. E 13 m
 N 6 m N, E, b, E. 5°. E 22 m.
 S, E, b, E. 5° E 22 m N 25 m
 E 10 m S 149 m W 28 m.

QUEST. XXI. Admit two
 Ships sail from a certain Island,
 in Lat. 30° N. to Cruise for
 13 Days; the first sails W. 40m.
 N, E 22m. N 30 m. W, N, W,
 15 m E, N, E, 15 m N 30 m
 N, W, 22 m E 40 m S, W, 20m
 S 30 m E, S, E, 15 m W, S, W,
 15 m S 30 m. The other
 Ship steers away, *viz.* E 40m
 N, E, 22 m N 60 m. N, W,
 22 m E 40 m S, W, 22 m S
 30 m N, E, 57 m W, N, W,
 17 m E 38 m W, S, W, 20 m
 S, W, 68 m N, E, 8 m S, E,
 68 m E, S, E, 17 m W 40 m
 E, N, E. 17m. N, W, 63m. I
 demand each Ship's *x.* Lat.
 Dep. Direct Course, and Dist.
 from the Island; also the La-
 titude they are both come in-
 to?

In this last Question, is proje-
 cted the Two First Letters of the
 AUTHOR's Name, in Roman
 Capitals.

To Measure BALES and CASES, and to find their Tonnage.

IT is of frequent Use in the River of *Thames*, for the Com-
 manders or Mates of Ships, (taking in Bale Goods,) to
 cast up their Tonnage. Now these Bales, &c. are generally
 Square

Square Prisms, or Long Square Solids; or to be esteemed so, if Round as a Cylinder, (or Rolling-Stone of a Garden;) because they occupy the same Space in the Hold as Square Ones: The General Rule for their Content in Feet, is,

To Multiply their Breadth, Depth, and Length together; and then, to reduce these Feet into Tuns, we must know how many Solid Feet is equal to a Tun: Till this is agreed on, no exact Answer can be found. And first, 'tis found by Experience, 66 Foot is the Content of a Case that incloseth Two English Buts; which is generally esteem'd as equal to One Tun. But then, this Rule excludes the Cantlings or Vacuity of the said Buts within the Case, which is allow'd to be something more than $\frac{1}{3}$ Part, or Feet. If therefore we allow the Cantlings or Vacancy to be 16 Feet, and deduct it from 66 Feet, rests 40 Feet to be accounted as One Tun. But Others again plead, that every Cubick Foot of Water, doth weigh 55 Pound Avoirdupoize: But Dr. Wybard, (who was very diligent this Way) finds every Cubick Foot of Water to weigh 62, lb. 588. Now in a Tun, or Twenty Hundred Weight, there is 2240 Pounds: And if you divide 2240 by 62, 588, the Quote is 35, 79 Feet; by this Experiment.

But $2240 \div 62 = 40, 7$, agreeing nearly with the first Way, and which we shall make use of; therefore the Rule is,

As 40 is to the Area of the End, so is the Length to the Content in Tuns.

Example I.

A Box, Bale or Case, whose $\left\{ \begin{array}{l} \text{Breadth } 6 \\ \text{Depth } 4 \\ \text{Length } 10 \end{array} \right\}$ Feet,

How many Feet and Tuns doth it contain?

Facit. 240 Feet, or 6 Tuns.

D. Ar. End.

Br. $6 \times 4 = 24$ Feet. $\times 10$ Feet $= 240$ Feet. Content,

And $4 \text{ (0) } 24 \text{ (0) } 6$ Tuns.

Ar. Base. Leng.

Or thus: As 40 -- 24 :: 10 -- 6 Tuns. Facit.

Note. If the Dimensions be taken in Feet and Inches, your best way is to reduce the odd Inches of each Foot into Decimals; which may be easily done by the following Table of the Decimals of Inches.

The TABLE.

Example II.

Inch.	Decims.
1	,083
2	,166
3	,25
4	,333
5	,416
6	,5
7	,583
8	,666
9	,75
10	,833
11	,916

A Bale, &c. whose

F. Inch.

Feet.

{ Breadth 4 : 3 }
 { Depth 2 : 8 } or per Table { 4,25 } What
 { Length 5 : 9 } { 2,66 }
 is the Content in Tuns Facit. 1, 65. Or,
 1 Tun, 13 C.

4,25 B.

2,66 D.

2550

2550

830

11,3050 Area of the End.

5,75 Length.

565250

791350

565250

66,063750 Content in Feet.

Divide by 4 } 66,063750 (1,65 Tun.

— Multip. by 20 the Hundreds in a Tun.

26

C. 13,00 Facit. 1 Tun. 13 C.

200

But, if the Learner is unacquainted with Decimal Arithmetick, he may reduce each Foot and Inches into Inches; and Multiplying the Dimensions into one another, the Content thus found in Inches, Divided by 1728, the Solid Inches in a Foot, gives the Content in Feet; and this, Divided again by 40, Quotes the Tuns.

Example III.

F. In.

A Bale or Case, whose { Breadth is 4,6 }
 { Depth 3,4 } What's the Con-
 { Length 9,2 }
 tent in Tuns ? Facit. 3 Tuns, 8½ C.

54 In B.

To Gauge a Cask which is full

Sworn Measurers: The Rule is thus, viz. Take $\frac{1}{3}$ Parts of the Ship's Breadth, and Subtract it from the Length, (taken from the Stern-Post, to the Foot of the Perpendicular dropt from the upper Part of the Stem;) the Remainder multiply'd by the Whole Breadth, and that Product again by the half Breadth; the last Product, Divided by 110 for *Kings*, or 94 for *Merchants*, (gives the) Tunnage.

Example.

Suppose a Ship, 74 Feet in Length (from the Stern-Post to the Foot of the Perpendicular, from the upper Part of Stem;) and her Extream Breadth, from Out-side to Out-side, 26 Feet: What is this Ship's Tunnage?

2) 26 (13. Half Breadth. And 5) 26 (5, $\frac{2}{5}$

$$\begin{array}{r} 1,0 \end{array}$$

F.

15,6 the $\frac{1}{3}$ Parts of (the Breadth.

Then from the Length 74,0

Take the $\frac{1}{3}$ of Breadth 15,6

$\frac{1}{2}$ Breadth

Refts

58,4 X 6 = 13,8,4; this X 13 = 197 39,12

1/00 197 139 (197, $\frac{139}{100}$ King's Tunnage.) and 94) 9739 (209 $\frac{9}{4}$, or very near 210 Tun, Merchant's Tunnage. *Facit.*



To Gauge or Measure a Butt, Pipe, Puncheon, Hogshead, Barrel, or any (Spheriodical) small Cask.

Rule.

YOU must first reduce it to a Cylinder, that is, find a mean Diameter between the Head and the Bung thus; find the Difference between the Bung and Head Diameter; this Difference multiply'd by $\frac{7}{12}$, and added to the Head Diameter, gives the Mean Diameter; this Sum Squar'd and Divided by 294, Quotes the Area of the Cask; which multiply'd by the Length, gives the Content in Wine Gallons; or if Divided by 359, the Quantity of Ale Gallons requir'd.

Example.

Suppose a Cask whose Bung Diameter is 31 Inches; Head Diameter 34 Inches, and its Length 47 Inches, what is the Content in Wine or Ale Gallons?

B. D. 31 — H. D. 34 = 3 X $\frac{7}{12}$ = 1,75

And H. D. 34 + 1,75 = 35,75 Mean Diam.

Then 35,75 X 35,75 = 1278,0625

And

To Gauge a Cask which is full.

379

And $\left\{ \begin{matrix} 294 \\ 359 \end{matrix} \right\} 835,21 \left\{ \begin{matrix} 2,84 \\ 2,32 \end{matrix} \right\}$ Area in $\left\{ \begin{matrix} \text{Wine Gallons.} \\ \text{Ale Gallons.} \end{matrix} \right.$
 Leng. Gall.

$2,84 \times 47 = 133,48$
 $2,32 \times 47 = 109,04$ } Content in $\left\{ \begin{matrix} \text{Wine Gallons.} \\ \text{Ale Gallons.} \end{matrix} \right.$

A TABLE for Gauging Wine-Casks, when full.

	Head Bung.			Head Bung.			Head Bung.			Head Bung.	
	D.	G. Pts.		D.	G. Pts.		D.	G. Pts.		D.	G. Pts.
The Diameter in Inches.	1	0,001	0,001	10	0,290	0,580	31	1,089	2,178	46	2,398
	2	0,004	0,009	1	0,328	0,517	32	1,100	2,211	47	2,503
	3	0,010	0,020	18	0,367	0,734	33	1,234	2,468	48	2,611
	4	0,018	0,036	19	0,409	0,818	34	1,310	2,620	49	2,721
	5	0,028	0,056	20	0,452	0,906	35	1,388	2,776	50	2,833
	6	0,041	0,081	21	0,500	1,000	36	1,469	2,938	61	2,948
	7	0,056	0,111	22	0,548	1,097	37	1,551	3,102	62	3,064
	8	0,072	0,145	23	0,599	1,199	38	1,636	3,272	63	3,183
	9	0,092	0,185	24	0,653	1,306	39	1,724	3,448	64	3,305
	10	0,113	0,226	25	0,708	1,416	40	1,813	3,626	65	3,428
	11	0,137	0,274	26	0,766	1,531	41	1,904	3,809	66	3,554
	12	0,163	0,326	27	0,826	1,652	42	2,000	4,000	67	3,682
	13	0,192	0,383	28	0,888	1,777	43	2,096	4,192	68	3,811
	14	0,222	0,444	29	0,953	1,906	44	2,194	4,388	69	3,941
	15	0,255	0,511	30	1,020	2,040	45	2,295	4,591	70	4,080

2. By this TABLE.

The Table shews for 24 Inches Head Diameter 0,653
 For the Bung Diameter 31 Inches 2,178
 Their Sum is the Mean Diameter ————
 Which Multiply by the Length ———— 47

Product is the Content Wine Gallons.

To turn Wine Gallons into Ale Gallons, and *contra*, this is the Proportion.

As $\left\{ \begin{matrix} 282 \\ 94 \\ 5 \end{matrix} \right\}$ is to $\left\{ \begin{matrix} 231 \\ 77 \\ 4 \end{matrix} \right\}$ so is the Content in Wine Gallons, to the Content in Ale-Gallons: For

Note,

To Gauge a Cask which is not full.

Note, The Wine Gallon contains 231, and the Ale Gallons 282 Solid Inches; or, 231 Gallons of Wine makes 282 Gallons of Ale.

The Use of this TABLE.

A TABLE for Gauging Wine Casks which are not full.

G. Parts	G. Parts	G. Parts	G. Parts
0	000	1980	314943
1	295	3056	5000
2	470	3123	5057
3	602	3189	5115
4	720	3255	5174
5	830	3321	5234
6	935	3387	5294
7	1038	3452	5354
8	1138	3517	5415
9	1235	3582	5476
10	1339	3647	5535
11	1420	3712	5600
12	1502	3777	5662
13	1596	3848	5724
14	1681	3906	5787
15	1764	3960	5850
16	1846	4024	5913
17	1918	4087	5976
18	2010	4150	6040
19	2091	4213	6094
20	2171	4276	6158
21	2242	4338	6223
22	2328	4400	6288
23	2405	4462	6353
24	2481	4524	6418
25	2556	4585	6483
26	2630	4646	6548
27	2703	4706	6613
28	2775	4766	6679
29	2847	4826	6745
30	2918	4885	6811
31			6877
32			6944
33			7012
34			7082
35			7153
36			7225
37			7297
38			7370
39			7444
40			7519
41			7595
42			7672
43			7758
44			7829
45			7909
46			7990
47			8072
48			8154
49			8236
50			8319
51			8404
52			8491
53			8580
54			8661
55			8765
56			8862
57			8962
58			9065
59			9170
60			9280
61			10000

The Table is made to Gallons and Half Gallons, and by Proportion may go nearer. Rule:

Find the Content of the whole Cask, and find how deep the Liquor is within the Cask; then say,

As the Diameter at the Bung in Inches, to the Depth of Liquor; so the Rad. of the Table 10000, to the Proportional Part, Find in the Table the Gallons and Parts, that answer that Part Proportional; then say again,

As 62 Gallons, the Gall. of the Rad. is to the Proportional Gall. found; so is the Content of the whole Cask, to the Content of the Liquor in the Cask.

Example.

Let the Cask be as before, 31 Inches at Bung, and the Liquor 24 Inches Deep.

As the Diam. at Bung 31 To the Depth of Liq. 24 So is the Radius 10000 of the Table

To the Part Prop. 7741

Find this Number 7741 (or nearest to it in the Table, and it answers very near to 52, $\frac{1}{4}$ Gall.

Then say again,

As the Gallons of the Radius
To the Proportional Parts found
So is the Content of the whole Cask,
To the Content of the Liquor being 24 Inches Deep 110, 114
That is, somewhat above 110 Gallons, and Three Quarts.

G. Pts.

63.00

52.5

133.0

110.14

*The Ullages of an English Butt that holds 108 Gallons,
Ale Measure; whose Head Diameter is 31 Inches,
and Bung Diameter 31 Inches, and Length 46 Inches.*

THE Use of this Table is plain and easie; for here is the Quantity of Gallons contain'd in the wet Inches of the Bung Diameter, under W; and the Wants, or (Dry) Gallons out, under D, against the Wet Portion.

B.	W.	D.	B.	W.	D.
0	G.P.	G. Pts.	0	G. Pts.	G.P.
10	54	107.46	12	61	546.30
22	00	106, 0	18	66	341, 7
34	03	103, 7	19	71	336, 3
46	00	102, 0	10	76	032, 0
58	399	721	80	028, 0	
612	096	022	84	523, 5	
716	891	622	88	619, 4	
819	488	624	91	616, 4	
923	584	115	96	013, 0	
1028	080	026	99	718, 3	
1132	076	026	102	06, 0	
1236	771	228	103	74, 3	
1341	766	529	06	02, 0	
1446	561	530	107	460, 54	
1551	556	531	108	000, 0	
1656	551	5			

The Decimals answering to Quarts and Pints, are

.25 = 1 Quarts. .5 = 2 Quarts.

.75 = 3 Quarts. .9, 179 = 1 Pint.

These Gallons of Ale may be turn'd into Wine Gallons by the Reverse of the Rule foregoing.

of GUNNERY.

TO find how much Powder is sufficient both for Action and Proof of any Piece of Ordinance, take this Rule. Multiply the Weight of the Ball, by the Calibers in the Circumference of the Breech; and for Proof, Multiply this Product by 8; for Service, Multiply the same by 6: This

last Product, Divided by 96, gives the Number of Pounds of Powder.

Example.

Suppose a Cannon Ball of Iron weighs 24 l. fit for a Gun whose Breech contains 9 Calibers, or Diameters of the Bore in Circumference; I demand the Quantity of Powder fit for Proof and Action?

Ball	24 l.	24 l.
Calib.	9	9
216	216	216
8	8	8

96) 1724 (18 l. Proof. 96) 1296 (13 $\frac{2}{3}$ or 13 l. for Service or Action.

This Rule is Short and Easie: Use it, or those deliver'd by Others; and let your own Experience prove or disprove it.



To make any DIAL to any Plane, whether Direct, Declining, Reclining or Inclining; Crooked, Bended, or any ways Uneven, without any notice taken of such Declination, Reclination, &c.

DO thus, by the help of a Large and Good Horizontal Dial, (to be had at the Instrument-Maker's,) which must have a small Hole in the Center, to suffer a Silk Thread or Hair to go through. You may work thus: Under the Plane, where you intend to make a Dial, draw a Level Horizontal Line, by a Carpenter's or other Level; to this Line set a Scaffold or Frame of any Board or Boards, deep, according to the Bigness you intend the Dial to be; this Scaffold must be Level likewise.

This being fitted, and by any other True Dial or your Minute-watch, rectify'd; find the true Time of the Day, and placing your Horizontal Dial upon the Level-Plane, keeping it to the true Time of the Day by moving it to and fro; you may, by the Thread from the Center, carried by the Edge of the Gnomon or Stile, find out the Center of the new Dial, if it will have a Center; which Mark, and by small Tacks fasten your Horizontal Dial in that Place; that it may not move the Thread or Hair carry'd by the Edge of the Gnomon;

mon, if continued in either Pole, and is the Gnomon to the New Dial; the Perpendicular Line under it, taken by a Square, is the Substylar, and the Style may be fastened to the Plane by help of that Thread.

Now to draw the Hour-Lines, do this, Lay the Thread fix'd to the Center of the Horizontal Dial, over the Hour-Lines and Quarters, and mark out in the Horizontal Line, on the Plane, where they Intersect: Lines drawn from the Center of the new Dial to these Points, are the Hour-Lines: But some Hour-Lines may run off the Plane, or by reason of their Crookedness, or some Pillars may hinder: to help this, draw as large a Square or Oblong upon the Horizontal Plane as you may, and transfer (by help of the Center-Thread) all the Hours from the Horizontal Dial, into the Lines of the Outside of the said Square or Oblong: Now if you bring a Thread from the Center of the New Dial, and rest it upon the Hour-Points mark'd in the said Square, the Center-Thread of the Horizontal Dial, carry'd only to touch the other Thread, will describe the Hour-Line desired, whether upon an Even or Uneven Plane, that have Centers for the new Dial: But if the Line carry'd by the Edge of the Gnomon of the Horizontal Dial, will not meet with the Plane, as in all East and West Planes much declining, then must you fix up a Board or other Matter, to receive the Center by the Side of the Plane, and then fixing a Thread there, by that and the other Thread, you may strike all the Hour-Lines, as was before shew'd, in Crooked Planes, and the Thread from the Centers, being the new Gnomon, must be fixed to the Wall by Two Stays.

This may be practis'd with as much Curiosity as any other, and will be Sure and Exact.

Of the most Rational Ways that have hitherto been propos'd to find the LONGITUDE at Sea, by Observation.

- Which are these Five, viz. I. By an Eclipse of the Moon.
 II. By the Moon's Place in the Zodiac given.
 III. By the Eclipses of Jupiter's Satellites, or Circumjovials.
 IV. By a Clock, Watch, or Hour-Glass.
 V. By the Distance betwixt the Moon and some known fix'd Star, situate near the Ecliptick.

If the Longitude could be as certainly found out at Sea, as the Latitude, it would render Navigation perfect. Yet hitherto, tho' many of the ablest Mathematicians in England, (and elsewhere) have attempted it, but never accomplish'd it. Theater, in his *Planisphere*, tells us, he can by that Instrument, as certainly find out Longitude, as to find the Rising, Setting, and Southing of the Stars: But if he could, he does very ill express it; and therefore, we may conclude, that *Aliquid latet quod non patet*; and perhaps he might keep a Reserve to himself on purpose. Others (since the late Act of Parliament has been pleas'd to offer such a Liberal and Plentiful Gratuity to him that shall first discover it) have exerted their utmost Industry for attaining that End: Some of whom have been so far from completing their Design, that they have rather render'd themselves and their Works ridiculous; by publishing such Absurd, Improper, and Improbable Methods. But to waive all these, we shall only insert such Methods as may seem most probable.

The Process for finding the Longitude of any Place, depends upon the Inequality of the Motion of the Celestial Bodies; for if both the fixed Stars and Planets, be mov'd with an Equal Degree of Velocity from East to West; every of these in the same number of Hours shall pass through all the Meridians of the whole Earth: But by reason of the Inequality of the Motion of the Celestial Bodies, if any fixed Star come to any Meridian at Twelve at Midnight, it shall come to that Meridian that is 90° Distant to the westward, at 11h. 59m. and consequently the Error of one Minute of Time in Motion, produceth an Error in Longitude of about 90 Degrees.

Also if the Moon (whose Motion is swiftest of all) comes to any Meridian at 12 a Clock: She shall come to a Meridian which lies $7^{\circ} 12'$ westward, about 11 h. 1 m. and therefore, from the Error of one Minute of an Hour in the Moon's Motion from the Sun, ariseth an Error of $7^{\circ} 12m.$ in the Longitude of the Place propounded: And in the Motion of the Moon from any fixed Star, riseth an Error of $6^{\circ} 48'$; and in the rest of the Planets, after the same manner, the Error increaseth; both from the Planet's Place, taken by Observation, and from the Tables calculated according to the Proportion between the Motion of the Planet observ'd, and the Motion of the *Primum Mobile*.

From which, we may infer, that seeing the Difference of Longitude cannot be obtain'd by help of Celestial Observations, unless the exact Time be known between both Places, whose

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Difference of Longitude is sought; it is obvious, that if the Errors at both Places be not of the same Denomination, and lesser than 1 Minute of Time, the Error of Longitude cannot be less than 13 Degrees.

Hence, 'tis manifest how difficult (if not impossible) it is, to find the Ship's Longitude at Sea, by Observation of the Celestial Bodies. However, the Design here is to shew the various METHODS propos'd, and that there is not such a Mystery in this Notion of Longitude, as our vulgar Seamen commonly imagine. See *Varenius* and *Carpenter's Geography*, P. 416, 417, 418, 420, &c. and *Newton's Idea. Nautic.* P. 79, 80, &c. collected from the same.

M E T H O D I.

To find the Longitude of any Place by an Eclipse of the Moon.

AT the Moment of Time, when through a good Telescope, you observe the Beginning, Middle, or End of an Eclipse, you must take the Altitude of a Fixed Star, whether it be upon the Meridian or in any Azimuth, it matters not: But if the Star be on the Meridian, you may (if you knew it not before) find the Lat. of the Place. Which Astral Altitude being taken, find the Hour of the Night with all possible Exactness; which is most easily done by this following Rule: *viz.* If the Star be upon the Meridian, to the Complement of the Sun's Right-Ascension in Hours and Minutes, add the Star's Right-Ascension in Hours and Minutes: The Sum is the Time requir'd. Compare this time of the Night thus found, with the time of the Beginning, Middle, or End of the Eclipse, found by the *Almanack* or *Ephemeris*, calculated for that Eclipse; and the Difference in Time, between the Place for whose Meridian the *Ephemeris* was calculated, and the Place where this Observation was made; and then the Long. of the Place where this Observation was made, may be found by converting the Hours and Minutes, in the Difference in Time between the Two Places, into Degrees and Minutes of the *Equator*.

This Method would be very accurate and useful, if we could see an Eclipse every Night: But as Eclipses seldom happen, and when they do, are not visible in all Places; therefore it is not so useful at Sea, being rather accommodated to the Shore: And thereby, the Longitudes of most Places were discover'd.

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METHOD II.

To find the Longitude of any Place, having the Moon's Place in the Zodiac given.

FIND the true Time in which the Moon comes to the Meridian; and thereby find the Longitude. Thus;

The Lat. being known in the Place of Observation; find the Altitude of any known Star, and thereby the Time of the Night with all imaginable Accuracy. (But note, that the Altitude of the Star, must be taken precisely when the Moon is upon the Meridian.) Next find what Degree or Minute of the Zodiac or Ecliptick is in the *Medium Celi*, at that same time exactly: And thus for the Time found, we have the Moon's true Place in the Zodiac.

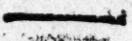
Then from the Tables calculated for the Meridian of that *Almanack* or *Ephemeris*, find the Hour in which the Moon shall be in that Point of the Zodiac; and we shall have the Horary Difference in Time, between the Two Places, *viz.* Of the Place where the Observation was made, whose Long. is unknown; and also, of that Place to whose Meridian the *Ephemeris*; was calculated: And then proceed as in the former Method.

METHOD III.

To find the Longitude of any Place, by the Eclipses of Jupiter's Satellites.

ABOUT the Glorious Planet *Jupiter*, there are Four Satellites, Moons or Companions, (Invisible to most naked Eyes, though very easily perceiv'd through a Telescope;) which continually move round about *Jupiter*, respecting him as their Common Center: Their proper Motion, by which they are carried about *Jupiter*, (for their Diurnal Motion, and their Motion in the Ecliptick, is common to all the fixed Stars, to *Jupiter* and the rest of the Planets,) is swift: That which is nearest to *Jupiter*, finisheth his Circuit, in

1 Day, 18 Hours, 28 Minutes, 36 Seconds.

		Days.	Hour.	"	"
The Second in		3	13	17	54
The Third in		7	03	59	36
The Fourth in		16	18	05	03

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A TABLE of the Eclipses of Jupiter's Satellites; Visible under the Meridian of the Observatory, Anno 1693.

January.			September.		
D. H. M. Satel.	D. H. M. Satel.		D. H. M. Satel.	D. H. M. Satel.	
2 8. 74. I.	10 7. 36. I. E.		5 14. 41. 2. I.	16 17. 45. 3. I.	
2 10. 51. 4. E.	10 8. 53. 4. E.		8 12. 32. 1. I.	16 13. 3. 1. I.	
3 11. 23. 2. E.	10 11. 54. 4. E.		10 15. 41. 4. I.	16 15. 46. 4. I.	
4 9. 40. 3. I.	17 9. 24. 1. E.		15 14. 27. 1. I.	16 20. 15. 4. E.	
4 12. 49. 3. E.	24 9. 13. 3. E.		19 13. 26. 3. E.	18 7. 30. 3. I.	
5 14. 02. 1. E.	24 12. 22. 1. E.		22 16. 23. 1. I.	22 19. 6. 2. I.	
7 8. 32. 1. E.	31 10. 00. 3. I.		26 13. 57. 4. I.	23 14. 53. 1. I.	
10 13. 58. 2. E.	April.		26 17. 27. 4. E.	25 9. 20. 1. I.	
11 13. 39. 3. I.	D. H. M. Satel.		27 14. 3. 4. E.	26 8. 22. 2. I.	
14 10. 24. 1. E.	27. 48. 1. E.		29 18. 18. 1. E.	30 16. 41. 1. I.	
16 4. 53. 1. E.	48. 17. 2. E.		December.		
19 5. 02. 4. E.	99. 45. 1. E.		D. H. M. Satel.		
21 5. 21. 2. E.	9 10. 56. 2. E.		2 11. 10. 1. I.		
21 12. 18. 1. I.	25 1. 8. 1. E.		3 9. 39. 4. I.		
23 6. 47. 1. E.	May.		3 11. 2. 2. I.		
28 8. 28. 2. E.	D. H. M. Satel.		3 14. 12. 4. E.		
28 14. 14. 1. E.	2 10. 3. 1. E.		7 18. 33. 1. I.		
30 8. 42. 1. E.	43. 8. 2. E.		9 13. 01. 1. I.		
February.			9 13. 26. 2. I.		
D. H. M. Satel.	69. 27. 3. E.		11 7. 28. 1. I.		
2 3. 50. 3. I.	10 9. 2. 4. I.		14 9. 26. 3. I.		
2 11. 52. E.	♄ ☉ 4		16 14. 51. 1. I.		
6 10. 38. 1. E.	July.		17 15. 57. 2. I.		
8 5. 71. 1. E.	D. H. M. Satel.		18 9. 18. 1. I.		
9 5. 48. 3. I.	3 15. 15. 2. I.		20 8. 8. 4. E.		
9 8. 53. 3. E.	5 15. 25. 4. I.		21 5. 13. 2. I.		
11 13. 33. 2. E.	15 15. 38. 1. I.		21 13. 22. 3. I.		
13 12. 35. 1. E.	1 13. 57. 1. I.		23 16. 4. 1. I.		
15 7. 4. 1. E.	August.		24 18. 29. 2. I.		
16 9. 43. 3. I.	D. H. M. Satel.		25 11. 10. 1. I.		
16 12. 55. 3. E.	4. 55. 2. I.		27 5. 39. 1. I.		
21 5. 41. 2. E.	7 15. 51. 1. I.		28 17. 18. 3. I.		
22 1. 11. E.	14 13. 53. 3. I.		30 18. 33. 1. E.		
March.			November.		
D. H. M. Satel.	1 17. 07. 1. I.		D. H. M. Satel.		
8. 21. 2. E.	23 14. 11. 1. I.		1 9. 52. 3. I.		
1 10. 50. 1. E.	30 16. 7. 1. I.		1 1. 28. 1. I.		
			1 13. 24. 3. E.		
			2 9. 19. 1. E.		
			7 16. 42. 1. I.		
			8 13. 49. 3. I.		
			8 4. 1. 2. I.		
			8 17. 20. 1. E.		
			9 11. 10. 1. I.		
			14 18. 34. 1. I.		
			15 16. 34. 2. I.		

A TABLE of the Eclipses of *Jupiter's* Satellites, Visible under the Meridian of the Observatory, or near it, Anno 1694.

January.			D H. M. Satel			May.			November.		
D	H. M.	Satel	D	H. M.	Satel	D	H. M.	Satel	D	H. M.	Satel
1	15.20	1. E.	24	4. 28	3. E.	5	9. 47	2. E.	3	17.57	1. I.
3	9. 48	1. E.	25	8. 21	4. E.	14	9. 31	1. E.	4	15.16	4. E.
4	13.03	2. E.	25	12. 9	1. E.	28	9. 43	3. E.	5	12.25	1. I.
5	4. 16	1. E.	27	6. 37	1. E.				12	14.16	1. I.
8	17.12	1. E.	March.			June.			16	18. 8	2. I.
10	11.40	1. E.	D	H. M.	Satel	D	H. M.	Satel	19	16. 7	1. I.
11	15.51	2. E.	2	10.14	2. E.	3	9. 34	4. E.	21	10.34	1. I.
12	6. 8	1. E.	3	8. 50	3. E.	6	9. 41	1. E.	23	13.30	3. E.
15	5. 4	2. E.	4	14. 6	1. E.	July.			26	17.47	1. E.
17	13.33	1. E.	6	8. 35	1. E.	♂ ☉ ♀			25	9. 54	2. I.
18	18.21	2. E.	9	12.43	2. E.	August.			28	12.24	1. I.
19	8. 2	1. E.	10	9. 16	3. I.	D	H. M.	Satel	December.		
19	8. 44	3. E.	10	12.52	3. E.	3	17. 3	1. I.	4	12.26	2. I.
22	15.18	4. I.	11	16.03	1. E.	5	16.32	2. I.	5	14.14	1. I.
22	13.39	2. E.	12	10.32	1. E.	19	15.23	1. I.	7	16.42	3. I.
24	15.07	1. E.	17	13.18	3. I.	28	15.16	4. E.	11	14.56	2. I.
26	8. 56	1. E.	27	16.55	3. E.	September.			13	16. 4	1. I.
26	12.43	3. E.	20	12.30	1. E.	D	H. M.	Satel	14	10.32	1. I.
28	4. 24	1. E.	22	7. 0	1. E.	11	15.39	1. I.	18	7. 28	2. I.
29	10.15	2. E.	27	7. 20	2. E.	12	17.19	3. I.	19	17.54	1. I.
31	17.20	1. E.	29	8. 57	1. E.	18	17.25	1. I.	21	12.21	1. I.
February.			30	15.18	4. I.	23	13.59	1. I.	23	16. 6	4. I.
D	H. M.	Satel	April.			October.			26	19.43	1. I.
2	11.40	1. E.	D	H. M.	Satel	D	H. M.	Satel	28	14.11	1. I.
4	6. 19	1. E.	3	9. 56	2. E.	1	13.26	2. I.	29	9. 13	2. I.
5	12.51	2. E.	5	10.56	1. E.	4	13.54	1. I.			
8	9. 25	4. I.	10	12.27	2. E.	8	16.02	2. I.			
8	14.05	4. I.	12	12.52	1. E.	11	12.50	3. E.			
9	13.46	1. E.	14	7. 21	1. E.	11	17.49	1. I.			
9	17.08	3. I.	15	9. 4	3. E.	15	18.38	2. I.			
11	8. 15	1. E.	16	10.06	4. I.	18	13 1	3. I.			
12	15.28	2. E.	21	9. 17	1. E.	18	16.49	3. E.			
16	14.42	1. E.	22	9. 28	3. I.	20	17.10	1. I.			
18	10.12	1. E.	22	13.25	3. E.	25	16. 4	1. I.			
19	18.06	2. E.	28	11.13	1. E.						
23	17. 25	2. E.	29	13.20	3. I.						

The Use of the foregoing Tables, collected from Mr. S. NEWTON's Idea. Geogr. & Nautic.

First, You must have in readiness a Telescope Twelve or Fourteen Foot long; which directed to *Jupiter*, will shew his *Satellites*; which otherwise, are inconspicuous to most Men.

2. This Table it self shews you all the the Eclipses of the Four *Satellites*, for every Month of the Year; and upon what Day of the Month, and Hour and Minute of the Day each Eclipse happens.

The Letter E, signifies the Emerision or End of the Eclipse; and I, the Immerision or beginning thereof.

Thus in the first Tabte against September 26, you find 13 H. 57 M. and in the responding *Satellite* Column, you find 4 $\left\{ \begin{array}{l} I. \\ E. \end{array} \right.$

The meaning whereof is, that upon September the 26th, at 15 Hours 57 Minutes, Afternoon, the 4th *Satellite* Immergeth or Entreth the Shadow of *Jupiter*; and consequently the Eclipse endeth. Also against December 2. stands 11 H. 10 M. I which shews, that the First *Satellite* Immergeth or beginneth to be Eclipsed that Day at 11 H. 10 m. Afternoon. And upon December 30th. the Table shews you, the same First *Satellite* Emergeth, or ceaseth to be Eclipsed, at 18 H. 33 M. Afternoon.

The Eclipses in these Tables, are such as are Visible in England: But to find when any other Eclipse, not Visible to us, but under some remote Meridian, happens; you must first take the Mean Revolutions of the *Satellite*: Then to find when the next Eclipse of the First *Satellite*, &c. will happen after October 1694. you must do thus:

To the given Time of the Catalogue (or Second Table) for October the 4th, viz. 15. H. 58 M. add the Time of one Revolution or Circuit, viz. 1 D. 18 H. 28'. 36". the Sum is 2 D. 18 H. 22' 36" which add to October the 6 D. 18 H. 28'. 36". viz. the Time of the next Immerision; and thus you may proceed for all the rest: And by the help of a Terrestrial Globe, rectify'd for the Latitude of London, and to the Day of the Month; you may find where any other Immerision or Emerision will be Visible.

Thus having shewn the Use of these Tables of the Eclipses of the *Satellites* of *Jupiter*; you must have ready (as was said before) for Use, a Tube or Telescope Twelve or Fourteen Foot long directed to him to discover these his Attendants; otherwise, they are not discernable by the naked Eye. Therefore, at the Time of Observation, which must

be always when some or other of *Jupiter's Satellites* are Eclips'd; you must find the true Time of the Night, either by the Altitude of a Star in any Azimuth, or by any Stars coming on the Meridian at that Time.

Then by comparing the Time between the Merid. for which the foregoing Tables were calculated, and that which you find either by the Culmination of any Star, or its Altitude upon any other Azimuth, you may attain the Difference of Time between these two Meridians; which Difference of Time, proceed with as directed in the first Method.

Note, In the foregoing Table of *Jupiter's Satellites*, calculated Anno 1694. you are to observe, the Eclipses of the First *Satellite* are the most convenient for determining the Longitudes of Places; not only because they happen more frequently, and may be distinctly seen with a good Telescope, Eight, Ten or Twelve Feet long; but also, because its Motion is found more Regular.

Also the *Satellites* of *Jupiter* having no sensible Parallax with the Earth, in every Position of *Jupiter* above the Horizon, they are conveniently observ'd.

Example.

Admit in a Ship at Sea, (or on some unknown Islands I were on Shore) October the 3th. I find by my Telescope, that the Immersion of the First *Satellite* is at 3 a-Clock, 48 Minutes past, in the Morning, viz by an accurate Observation taken, of some known Star's Altitude, (or when a Star was upon the Meridian :) But by the foregoing Table for 1694. I find the Immersion to be at 14 Hours 41 Minutes, or 2 H. 41 M. Therefore from the observed Time, 3 H. 48 M.

	H.	M.
Adding 12	15	48
Subtract the Tabular Time	14	41
The Remainder is	1	07

Which Reduced to Time thus;

H.	M.
1	07
5	
5 : 35	} Multiply by the Ratio of 15 viz. 5 and 30
5	

16 : 45 The Difference of Longitude between the Meridian of the Ship, (or Place) and that of the Place for whose Meridian the Table was calculated.

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As to this *Third Method*, by the Eclipses of *Jupiter's Planets*, this must be own'd of much greater Use; since the Quickness of their Motion, especially as to the First or Innermost, makes the Moment of their Immersion into, or Emergence from *Jupiter's Shadow* very distinct and nice; and their Frequency, which is almost one for every Day, render them fit for the constant Uses of Navigation. Nor have we any Method so useful to discover the Longitude at Land, as this. Yet this Method labours under Difficulties scarce to be remedy'd: *viz.* 1. The best Tables of their Motions, for want of a sufficient Number of Observations, are not arriv'd to their desir'd Perfection; to be at all Times depended on, to be put in Practice. 2. The Difficulty, if not Impossibility of finding true Time at Sea. 3. The Improbability of managing a Telescope of Ten, Twelve, or Fourteen Foot long, that State of Tossing, Agitation, and Rowling Motion of a Ship at Sea. 4. The Impossibility of seeing these Eclipses, for about Three Months every Year, when the Planet *Jupiter* is near the Rays of the Sun; or when he is below the Horizon; renders this Method, at present, but of small Use in Navigation.

METHOD IV.

To find the Longitude of any Place by Automata's, or Unerring-Clocks, Watches, or Hour-Glasses.

First, BY Sand-Glasses: You are to prepare a very perfect and true Running-Glass, which may precisely run 24 Hours without Error. And at the Time you set sail from the Land, set the Glass a-running that Day, just at Twelve a-Clock at Noon, when the Sun is upon the Meridian: Being run out, be sure to turn the said Glass instantly as it is out, not losing any Time in the Turning of it. And so having very warily kept the said Glass; till you think good to make an Observation; at which Time, it is requisite to have in readiness, an Half Hour, Minute, and Half Minute-Glass; that if the 24 Hour-Glass be out, before the Sun comes to the Meridian, then so soon as it is out, to turn the Half Hour, Minute, or Half Minute-Glass, as you see occasion; thereby to know exactly how much the 24 Hour-Glass is out, before the Sun comes to the Meridian: For if the Sun is upon the Meridian, just when the 24 Hour-Glass is out, then you may assure your self you have sail'd North or South, and are still under the same Meridian you were at first:

But if the 24 Hour-Glass be out, before the Sun comes to the Meridian, for every Four Minutes that the Glass is out before Noon, your Difference of Longitude is 1 Degree to the Westward; and for every Hour 15 Degrees: And contrary, if the Sun comes to the Meridian before the Glass is out; then according to the same Proportion of Time, is your Difference of Longitude to the Eastward of the Meridian you departed from.

Secondly, By a Good Watch, that hath been observ'd a-shore to keep a True and Equal Motion: But here we must observe, that if the Watch be never so exactly made, yet it will not keep equal Pace with the Sun, or a True Sun-Dial; but go Faster or Slower, according to the following Table of Equation of Time.

The Use of this Table is very plain; for find the Month at the Top of it, and the Day of the Month at the Left Hand, and in the common Angle of meeting, You have the Equation in Minutes and Seconds, whether it be too Fast or too Slow, as the Title (*Watch too fast,*) or (*Watch too slow*) directs. Therefore, if you set your Watch or Clock exactly with the Sun, when the Equation is Nothing, (as on the Sixth of June,) it will after that always hold the same Equation found in the Table, whether too Fast or too Slow: And the Quantity (if your Watch go right;) and so likewise at any Time, if you set your Watch when there is Equation; you must give it the Equation answering to that Month and Day, (whether too Fast or too Slow) and then it will also hold the same Equation: For a Good Watch or Clock divides Time equally; but the Sun, by Reason of some Inequality in his Motion, divides the Time unequally: So that if the Sun, and a true going Watch, be set together at some Times in the Year, yet the said Watch will sometimes differ 10, 12, nay sometimes 16 Minutes from the Time given by the Sun; and yet no Fault in the Watch (as before said.) This Table will serve for many Years, without any sensible Alteration.

Days
Days

Days	January		Februa.		March.		April.		May.		June.	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	9	4	14	48	10	4	0	45	4	10	1	2
2	9	26	14	46	9	47	0	28	4	11	0	50
3	9	48	14	44	9	30	0	12	4	12	0	37
4	10	10	14	41	9	13	0	3	4	13	0	25
5	10	31	14	37	8	55	0	18	4	12	0	1
6	10	51	14	32	8	37	0	33	4	11	0	0
7	11	9	14	27	8	19	0	43	4	10	0	13
8	11	27	14	21	8	1	1	2	4	8	0	26
9	11	45	14	15	7	43	1	16	4	6	0	39
10	12	2	14	7	7	25	1	28	4	3	0	52
11	22	18	13	59	7	6	1	41	4	0	1	4
12	13	34	13	50	6	47	1	54	3	56	1	17
13	13	47	13	41	6	28	2	6	3	51	1	30
14	13	2	13	31	6	10	2	16	3	46	1	43
15	13	15	13	21	5	51	2	27	3	40	1	56
16	13	27	13	10	5	32	2	38	3	34	2	8
17	13	38	12	59	5	14	2	48	3	28	2	32
18	13	48	12	47	4	55	2	57	3	21	2	44
19	13	58	12	25	4	36	3	6	3	13	2	56
20	14	7	12	22	4	17	3	14	3	5	3	7
21	14	15	12	8	3	50	3	22	2	56	3	19
22	14	22	11	54	3	40	3	30	2	48	3	30
23	14	28	11	40	3	22	3	37	2	39	3	41
24	14	34	11	24	3	3	3	43	2	29	3	51
25	14	38	11	9	2	45	3	49	2	19	4	1
26	14	42	10	54	2	26	3	53	2	9	4	11
27	14	45	10	38	2	9	3	57	1	59	4	21
28	14	47	10	21	1	51	4	01	1	48	2	29
29	14	48			1	34	4	4	1	37	4	37
30	14	49			1	17	4	7	1	25	4	45
31	14	49			1	1			1	14		

Days

Days	July.		Aug.		Sept.		Octob.		Nov.		Dec.	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	4	45	4	28	3	53	13	18	15	21	5	35
2	4	53	4	18	4	14	13	32	15	13	5	06
3	5	6	4	8	4	34	13	46	15	03	4	38
4	5	7	3	57	4	55	13	59	14	53	4	09
5	5	13	3	47	5	15	14	11	14	41	3	40
6	5	18	3	37	5	36	14	23	14	29	3	10
7	5	24	3	27	5	56	14	34	14	17	2	40
8	5	29	3	8	6	17	14	44	14	03	2	10
9	5	33	2	55	6	38	14	54	13	49	1	40
10	5	36	2	42	6	58	15	04	13	34	1	11
11	5	39	2	27	7	19	15	13	13	17	0	41
12	5	42	2	13	7	39	15	22	13	00	0	11
13	5	44	1	58	7	59	15	28	13	43	0	19
14	5	45	1	42	8	19	15	34	12	24	0	49
15	5	46	1	26	8	38	15	40	12	05	1	19
16	5	46	1	9	8	58	15	45	12	45	1	49
17	5	45	0	52	9	18	15	50	11	25	2	18
18	5	42	0	35	9	37	15	53	11	04	2	47
19	5	40	0	17	9	57	15	56	11	42	3	16
20	5	38	0	1	10	16	15	58	10	20	3	45
21	5	34	0	18	10	34	15	59	10	56	4	14
22	5	30	0	36	10	52	16	01	9	32	4	42
23	5	26	0	55	11	10	16	00	9	08	5	09
24	5	20	1	14	11	28	15	59	9	43	5	36
25	5	14	1	34	11	45	15	57	8	17	6	04
26	5	8	1	53	12	02	15	54	8	51	6	39
27	5	2	2	12	12	18	15	51	7	25	6	57
28	4	52	2	32	12	33	15	47	7	59	7	24
29	4	46	2	52	12	49	15	41	6	32	7	48
30	4	35	3	13	13	04	15	35	6	03	8	12
31	4	32	3	33			15	29	6		8	37

The Use of this Table, as to determining the Difference of Longitude, is thus; Being provided with a good Watch, that you know by Experience to have kept a True and Equal Motion on Shore; when you set Sail, or depart from the Land, observe in the Table of Equation of Time, how much the Watch is too Fast or too Slow; and set your Watch to it, as before directed, and not to the Time of the Day by the Sun, unless it be when the Equation is Nothing. As for Example;

Suppose I sail from any Port upon a Voyage, upon the 27th of November, when the Equation in the Table is 7 M. 25 Seconds, and the Title *Watch to Slow*: I conclude from thence, that a good Watch should be 7 M. 25 S. to Slow, or behind the Time given by a true Sun-Dial. Therefore I put my Watch 7 M. 25 S. behind the Time given by the Sun; as suppose I set my Watch at 12 a-Clock, I put it 52 M. 35 S. past 11 a-Clock. And then provide a little Square or Round Box of about Four or Five Inches Broad; and having it fill'd with Fine Cotton, taking part of the Cotton out, and putting the Watch in the Middle of the Box, upon the Cotton you leave in the Box; and put the rest you took out, upon the Watch closely; and shut the Box, keeping it in some Dry Place, as in your Cabbin, or upon some Shelf near your Bed: And this to hinder the Alteration of Air, in different Climates, from having any Effect on the Movement, to cause it to go faster or slower. Then, supposing you have sailed Eastward, your Watch will want something of Twelve a-Clock; if Westerly, it will be more than Twelve by the Watch. Admit then I find the Sun just upon the Meridian; and find by my Watch it is 16 m. 15". after 2 a-Clock, and looking in the Equation-Table for the Day of the Month, (suppose Feb. 18.) I find my Watch too Fast 12 M. 47 S. Therefore Subtract 12 M. 47 S. from the Time given by the Watch 2 H. 16 M". the Remainder 2 H. 3 M. 28". Reduced as in the First Method, gives $30^{\circ} 51'$ the Difference of Long, but if it had been too Slow 12'. 47". you must have added 12'. 47". to 2 H. 16'. 15". the Sum 2 H. 29'. 02". would give the Difference of Longitude, viz. $37^{\circ} 15' \frac{1}{2}$. 'Tis thought, that if this Method was carefully put in practice, by our Commanders, &c. at Sea, it would render the Business of Longitude practicable; but we would advise, not to confide so much therein, as to omit any of the Methods of a *Journal*, or usual Precautions to preserve a Ship, when she approaches near Land.

METHOD V.

To find the Longitude of any Place, by the Appulses and Occultations of the fixed Stars by the Moon. See Dr. Halley's Appendix to Mr. Street's *Astron. Carol.*

There have been other *Methods* for the Discovery of Longitude ; as,

METHOD VI.

THE Variation of the Needle from the North, is now, especially since Dr. Halley's notable Observations, and Map thereto relating, become one Method for this Purpose : Particularly in those Parts where the Variation is best known ; and the North and South Position of its Lines are most remarkable. For by crossing the Meridians, there you also cross the *Curves* of Equal Variations, and discover in some measure your Longitude thereby.

But in this Case also, the Curve-Lines of the Variation of the Needle, are of small use ; because the Laws of that Variation, are not yet brought to a sufficient certainty ; notwithstanding the most useful Endeavours of Dr. Halley in that Matter. The Neighbourhood of Iron Mines, of Iron, or of Loadstones themselves, do sometimes disturb the General Rules, and deceive the Observers of that Variation. The Position of those Curves too far Eastward or Westward, in a great part of the World, renders this Variation useless, as to any general Discovery of the Longitude. And even there, where the Position of those Curves is the most Advantageous ; as it is about the *Cape of Good Hope*, and a considerable Way on both Sides of it ; yet is the Distance of those Curves, for the Difference of One Degree of Variation, about 100 Geographical Miles, i. e. near 2 Degrees of a great Circle : And to this Method, (as well as the others) as yet, is incapable of Longitude very nicely in any Case whatsoever.

Yet this Method may be greatly improved, by the Contrivance of the Magnetical Variation of the Needle.

VII. Another Method hath been propos'd for this purpose, by certain fixed Stars, chosen for each Time of the Year, &c. but is altogether absurd, as might be easily prov'd, had I room.

VIII. Another to explicate a New Method for finding the Longitude, proposes a new Theory of a Threefold Motion of the Earth : viz. 1 From West to East call'd the *Diurnal*, making its Revolution about its own Axis in 24 Hours. The

2d. its Motion towards the North, $23^{\circ}\frac{1}{2}$. one Half of the Year; and the 3d. its Motion towards the South $23^{\circ}\frac{1}{2}$. the other Half Year.

IX. Mr. *Whiston*, M.A. and *Humphrey Ditton*, Math. presents us with another *Method* for the Discovery of Longitude, from the Exploſion of Sounds of Great Guns, from Stationary Ships, Buoys or Marks in the Sea, at ſuch a Diſtance from each other; and of Bombs or Fireworks being fir'd up, &c. But I ſhall wave theſe, and leave it to the Authors to try their own Experiments, if they pleaſe.

Laſtly, The laſt *Method* I ſhall mention, is that of Mr. *W. Blundell*, by his Circles of Reverſion, inverting the *Mariner's* Compaſs, from North to South, and from South to North, &c. For which I refer the Reader to his Book in *Folio*, which he hath plentifully ſpread abroad, *gratis*; having not room to enlarge here.

*An ESSAY to find the Annual Variation of the Needle;
at all Times, all Seasons, and all Places or Latitudes.*

DEFINITION.

THE Declination or Variation of the Needle is uſually obſerv'd by Mathematicians and Mariners, by comparing the Azimuth of the Sun with the Diſtance of the Needle from the North or South Points of the Meridian; but erroneouſly, by Reaſon that the Needle continuing its ſtanding, and the Sun's Azimuth altering every minute of the Day; the Variation, or Difference of the Azimuth of the Needle from the Sun's, cannot be at all Times alike: And therefore, the Variation of the Needle in the Compaſs, not truly to be found by this *Method*.

On which Conſideration, we judge, that there could be no ſufficient Proof of the Needle's Variation, unleſs by a due length of Time or Annual, ſuch an Equation were found betwixt the Standing of the Needle, and Azimuths, cauſ'd by the Sun's Motion in the Ecliptick; whereby might be demonſtrated the Variation of the Needle.

To which purpoſe, the Honourable *Edward Howard* made Obſervations on both Sides of the Wall that ſurrounds *Windsor-Caſtle*, not conſiderably different: He found the Needle to Point at 13° , and to find its Annual Variation in both theſe Places, he gives us this ſubſequent *Theorem* thus worded.

THEO-

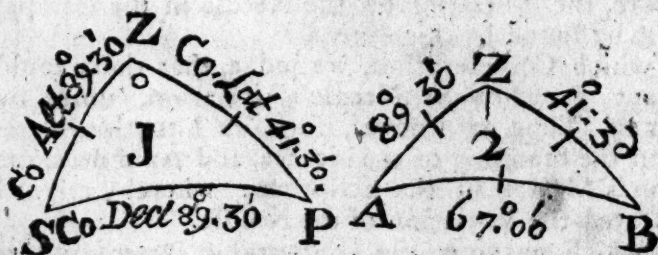
THEOREM.

IF betwixt the Sun's Declination of 30 minutes from the Equator; as also, his Altitude 30 minutes (or less if need be thought necessary) be taken, the mean Proportional Sine, betwixt his Azimuth at 30 minutes Declination, and Altitude, add the Standing of the Magnetical Azimuth; and next that, the same be done from his greatest Declination, wanting 30 minutes, and 30 minutes of Altitude; and the Difference taken betwixt both the Mean Proportionals so found: It is probably the most certain Way to find the Variation of the Compass in any Place; for all Times and Seasons of the Year in any given Latitude.

To render the more practicable the great Publick Use of the Compass at Sea, and whereby may be demonstrably avoided and detected, the common Errors incident to Navigation, as usually observ'd in the Variation of the Compass, in Voyages on the Ocean; Let us apply the precedent Theorem.

PROB. I.

Suppose a Ship sails from *Portland* in *England*, in Lat. $50^{\circ} 30'$. N. to *Lisbon* in *Portugal*, in the Lat. of $38^{\circ} 45'$. N. and it were requir'd to find the Variation for every 2° . of Lat. in the Voyage, the Diff. of Lat. is $11^{\circ} 45'$. There is constantly given the least Altitude and least Declination each $30'$. as also the Sun's greatest Declination wanting $30'$. and least Altitude $30'$. which you may resolve, with Application to the pointing of the Needle, by these Two Spherical Triangles, viz.



In the First Triangle is given Complement of the Lat. found at Sea, i. e. $P. Z. = 41^{\circ} 30'$. the Comp. of $30'$. of Altitude, $Z. S.$ the Comp. of $30'$. of Declination to 90° . $S. P.$ To find $S. Z. P.$ the Sun's Azimuth by the 19th. Prob. of *Astronomy* foregoing,

is = $89^{\circ}.50'$. whose Sine is 9.9999981
 And this Azimuth in the Needle, we will suppose } 9.3520880
 to be 13° . whose Sine is

Their Multiplication 19.3520861

Their Half, and Mean Proportional $28^{\circ}.18'.\frac{1}{2}$ 9.6760430

For the First Operation in the Triangle S L P.

In the Second Triangle A Z B, the Azimuth will be
 found to be = $54^{\circ}.34'$. whose Log. Sine is 9.9110460
 Azimuth of the Needle as before 13° . Sine 9.3520880

Their Multiplication 19.2631340

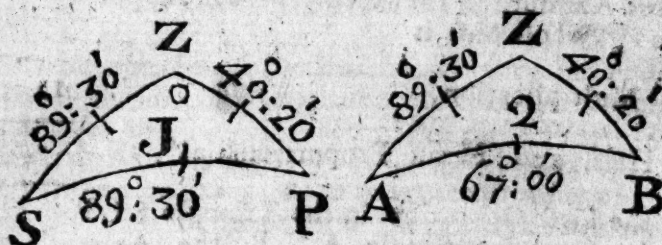
The Half, and mean Proportional, is $25^{\circ}.50'$ } 9.6315670
 First Mean Proportional Subt. $28 : 18$ }

Variation $2 : 28$ for the 1
 Quarter of the Ecliptick, in Lat: $48^{\circ}.30'$. That is, when the
 Ship was in Lat. $48^{\circ}.30'$. N. the certain Variation of the Com-
 pass was for one Quarter of the Ecliptick; which includes all
 the Varieties of the Sun's Annual Motion: The Needle
 being suppos'd to point as permanent at Sea, as it is observ'd
 on Land, &c.

By this manner of Triangular Solution, it were no hard
 Labour to prepare a Table beforehand, in which might be
 inserted all the Azimuths for every 2 Deg. of the Diff. of
 Lat. decreasing to the $11^{\circ}.45'$. as the Ship sails from *Port-
 land*; and also by the same Method for the last $1^{\circ}.45'$.
 which compleats all the Azimuths to the Port of *Lisbon*: There
 being nothing more requir'd, than carefully to observe the
 Latitudes in sailing, which most knowing Mariners can dex-
 terously perform.

EXAMPLE II.

I N Lat. $99^{\circ}.40'$. Magnetical Azimuth 8° . What's the
 Annual Variation?



In the Triangle SZP , is given $SP\ 89^\circ\ 30'$, $SZ\ 89^\circ\ 30'$, and $ZP\ 40^\circ\ 20'$, to find the $\angle SZP$, which is $= 89^\circ\ 50'$.
 The Sun's Azimuth $19^\circ\ 50'$.
 Magnetical Azimuth $8^\circ\ 00'$.

Sine 9.9999981
 Sine 9.1435555

Z is 19.1435536

First Mean Proportional $= 21^\circ\ 54'$

9.5717768

In the Second Triangle AZB , the Azimuth of the Sun at greatest Declin. wanting $30'$, and Altit. $30'$, is $S. 9.9057386$
 Magnetical Azimuth 8° .
 S. 6.1435555

Z is 19.0492941

Half and mean Proportional, is $= 19^\circ\ 33'$

9.5249470

The first mean Proportional, is $21^\circ\ 54'$

Second Mean Proportional, is $19 : 33$

Variation

$2 : 21$

At $49^\circ\ 40'$ N. Lat. for 1 Quarter of the Ecliptick, that is, $2^\circ\ 21'$. $X_4 = 9^\circ\ 24'$. Variation in that Lat. and the Needle stood at 8 Deg. according to Dr. Halley's Chart.

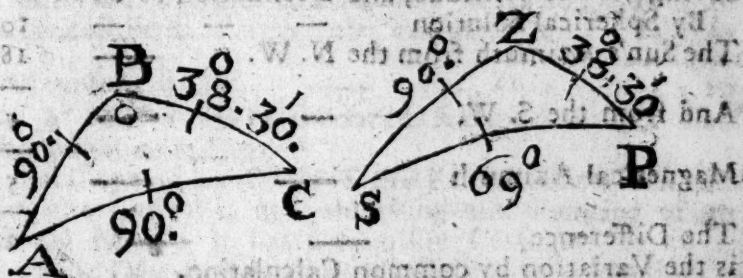
By this Process, suitable to the *Theorem*, if observed from 2 Deg. $\propto$ Lat. or as often as Opportunity may be had, from the Port whence the Ship sail'd from, to the End of the Voyage at Sea; the Course will be directed more commodiously certain, and less expensive to Trade and Commerce, &c. with a further Improvement of that excellent, secret, and great guide of Navigation, the Compass.

For further apprehending the erroneous *Method* of Calculation, vulgarly used at Sea, in finding the Megnetical Variation, compar'd with the Amplitude, Ortive or Occasive, or Azimuth of the Sun.

As

As to Amplitudes commonly observ'd at Sea; one Example may suffice instead of more.

In Lat. $51^{\circ} 10'$ N. The Sun having 21° Declination N. the Magnetical Amplitude, observ'd at Sun-setting, was 49° from the North, Westward. According to the Process in these Two Triangles hereunder: In the First, the Sun having no Altitude at Setting. I take for the Side A B a Quadrant, or 90° , as also the Side A C 90 , representing the whole Quadrant of the Ecliptick, or Distance of the Pole C to A; the Place of the Sun in the Ecliptick, in the Triangle A B C.



By Solution of which Triangles, I find the First Mean Proportional Sine $53^{\circ} : 48'$

And of the Triangle S Z P, I find the Second Mean Proportional Sine $47^{\circ} : 05'$

Their Difference $6 : 43$

And true Magnetical Variation from the Amplitude found, or the same with the Azimuth, the Sun having no Altitude, which is $6^{\circ} 43'$; that is, the North Point of the Magnetical Amplitude, declines from the true North, or Intersection of the Meridian and Horizon $6^{\circ} 43'$, towards the West.

Whereas by usual Computation at Sea, the Magnetical being $49^{\circ} : 00'$

The Amplitude found would be $35^{\circ} : 08'$

Variation $13^{\circ} : 52'$

Variation per Theorem $6 : 43$

The Difference is $6 : 09$

So considerable an Error is committed in the ordinary Calculation of Navigators by Amplitudes, which evidently is such, in not computing the True Variation instead of the Apparent of the Magnetical; according to this Process or Theorem.

Note, That after Sun-rising, the Calculation being made by the *Theorem*, the Azimuth and Variation would be the same for that Day, whilst the Lat. had no considerable Alteration; which by common Observation at Sea, would have an erroneous Difference. The like may be found in the usual Observations of the Magnetical Azimuths on the Ocean, compar'd with the Sun's: Which I shall represent to any impartial Judge.

EXAMPLE I.

The First of May, 1732, at Sea, in the Lat. 59° . N. the Sun having 30° . of Altitude, and Declination 18° . 7'

By Spherical Solution 105° . 20'
The Sun's Azimuth from the N. W. $180 : 00$

And from the S. W. $74 : 40$

Magnetical Azimuth $53 : 30$

The Difference $21 : 10$

is the Variation by common Calculation.

By the Process in the *Theorem*, the Variation is found $\left. \begin{array}{l} 21 : 10 \\ 16 : 34 \end{array} \right\}$

Erroneously fail'd $4 : 36$
according to the usual Calculation of Mariners.

EXAMPLE II.

IF on the same Day the Altitude of the Sun had been but 20° . when the Lat. and Declination of the Sun could have no considerable Alteration: Then the Azimuth observ'd from the N. or S. Westward, by common Observation at Sea, would be 88° . 04'

The Magnetical, as before standing $53 : 30$

Difference would be in the Variation $34 : 34$

By the Process in the *Theorem*, it is but $16 : 30$

Which proves the Error to be $18 : 04$

Such a vast erroneous Difference in a Maritime Voyage is only to be avoided by the certain Operation of the preceding *Theorem*.

EXAMPLE

EXAMPLE III.

M. P. 9th. 1732. before Noon in Lat. 58° North, the Sun having 32° of Altitude and Declination $19^{\circ} 59'$, the Magnetical Azimuth was 53° from the South Eastward.

By common Observation, the Sun's Azimuth $2108^{\circ} 14'$ from the N. Westward $5180 : 00$

And therefore from the S. Westward
Magnetical Azimuth $71 : 46$
 $53 : 00$

By common Observation the Diff. and Variation $18 : 46$
By the Process in the *Theorem*, the Variation is $14 : 27$

The Diff. and Error is $4 : 19$
That is, $4^{\circ} 19'$, or 259 m. erroneous from the Proper Coast the Ship ought to sail to.

The Facility and Exactness of this Process being such, that knowing the Latitude, and observing the Pointing of the Magnetical Needle, it has a requisite Certainty, as to all Times of the Day, and Seasons of the Year; including by the Magnetical Variation found, all the Mean Proportional Azimuths, infinitely Increasing and Decreasing to a Quarter of the Ecliptick, betwixt the Standing of the Needle, and the Course of the Sun; as before-mention'd, which implies all the Varieties of his Annual *Phænomena* and Azimuths to that purpose, and is the most Commodious and Practical Proof of the Doctrine of *Fluxions*, much improv'd by our Famous Sir *Isaac Newton*, that I believe is as yet understood.

All which Examples, we hope, may be acceptable to the Science of such of the Learned that are zealous for the Publick Good, and Improvement of the Noble *Art of Navigation*, &c. To whom I wish, Prosperity may attend their Sails and Landable Undertakings.



A SHIPS Tackling describ'd.

See Plate 3d. The Draught of SHIP.

- | | |
|--------------------------|---------------------|
| 1 } The Ensign | 5 } Cross jack yard |
| 2 } Mizzen Vane | 6 } Mizzen yard |
| 3 } Mizzen top sail | 7 } Main Vane |
| 4 } Mizzen top sail yard | 8 } Main pendant |
- K k 2

9 The

9	Main-top-gallant-sail,	h	Main-top-sail-braces
10	Main-top-sail,	k	Main-top-sail-clew-lines
11	Main-sail,	l	Main-top-sail-leach-lines
12	Fore-wane,	n	Main-top-sail-bunt-lines
13	Fore-top-gallant-sail,	m	Main-lifts.
14	Fore-top-sail,	o	Main-yards
15	Fore-sail,	r	Main-braces.
16	Jack,	s	Main-sheets.
17	Sprit-sail-top-sail,	t	Main-tacks.
18	Sprit-sail,	u	Fore-Mast.
19	Fore-top-gallant-stay,		Fore-top-gallant-mast
20	Fore-top-gallant-bowlines	a	Fore-top-gallant-lifts
21	Fore-top-mast-stay,	b	Fore-top-gallant-lifts
22	Fore-top-sail-bowlines,	c	Fore-top-gallant-yard
23	Crane-line,	d	Fore-top-gallant-braces
24	Fore-stay,	e	Fore-top-mast
25	Main-stay,	f	Fore-top-mast-back-stay
26	Main-top-mast-stay,	g	Fore-top-sail-lifts
27	Main-top-gallant-stay,	h	Fore-top-sail-braces
28	Main-top-gallant-bowlines	k	Fore-top-sail-clew-lines
29	Fore-top-gallant-braces,	l	Fore-top-sail-leach-lines
30	Fore-top-sail-braces,	m	Fore-top-sail-bunt-lines
31	Main-top-sail-bowline,	n	Fore-lifts
32	Galleries,	o	Fore-yard
33	Poop-Lanthorn,	p	Fore-leach-lines
34	Main-top-sail-brace,	q	Fore-bunt-lines
35	Mizen-Mast,	r	Fore-braces
36	Main-mast,	s	Fore-sheets
37	Fore-mast,	t	Fore-tacks
38	Bow-sprit,	u	Fore-shrouds
39	Mizen-top-sail-lifts,	x	Fore-clew-garnet.
40	Mizen-crow-foor,		Bow-Sprit.
41	Hoisting-line for a Flag	a	Sprit-sail-top-mast
42	or Pendant,	b	Sprit-sail-top-sail-lifts
43	Mizen-sheet,	c	Sprit-sail-top-sail-yard
44	Mizen-top-mast,	d	Sprit-sail-top-mast-shrouds
45	Mizen-top-sail-brace	e	Sprit-sail-top-sail-braces
46	Mizen-top-sail-clew-line	f	Sprit-sail-top-sail-crow-foot
47	Mizen-top-sail-sheet.		Sprit-sail-top-sail-sheets
48	Main Mast.	g	Horse on the bow-sprit
49	Main-top-gallant-mast,	h	Standing-lifts for sprit
50	Main-top-gallant-lifts,	l	Sail-yard
51	Main-top-gallant-yard,		Sprit-sail-yard
52	Main-top-gallant-braces,	m	Sprit-sail-sheets
53	Main-top-mast,	n	Sprit-sail-clew-lines
54	Main-top-mast-back-stay	o	Green line
55	Main-top-sail-lifts,	r	The



The Young Seaman's DICTIONARY :

O R,

An Explanation of the most Usual SEA-TERMS,

In an Alphabetical Order.

A.

AFT or *Abaft*, towards the Stern of the Ship; as, the Mast hangs aft: That is, towards the Stern.

How cheer ye fore and aft? That is, how fares all your Ship's Company?

Amain; a Word used by a Man of War to his Enemy, and signifies to Yield.

Strike Amain; that is, Lower your Top sails.

The Anchor is A-peek, viz. Right under the Ship's Bow or Hawse-hole.

The Anchor is a-Cock-bell; that is, hangs up and down by the Ship side.

The Anchor is foul; that is, the Cable is got about the Fluke.

An Awning; a Sail, or the like, supported like a Canopy over the Deck, to prevent the scorching Heat of the Sun in Hot Climates.

B.

TO Bale; to lade Water out of the Ship's Hold, with Buckets, or the like.

Trench the Ballast; Divide or separate it.

The Ballast shoots; that is, it runs over from one side to the other.

To Bear in with the Land, &c. to sail towards it.

To Bear in; that is, to sail before, or with a Wind, into an Harbour or Channel.

A Piece of Ordnance (or great Gun) doth come to Bear; that is, lies right with the Mark.

Bear up; a Term used in Conding the Ship, when they would have her sail more before the Wind.

Bear up around; put her right before the Wind.

To Be-laze; to make fast any running Rope.

K k 3

To bend a Cable, is to clench or make it fast to the Ring of the Anchor.

A Bitch; a convenient Place for a Ship to Moor or Ride at Anchor in.

A Bight; any part of a Rope between the End, when doubled together.

The Bilge; the Breadth of the Place the Ship rests on, when she is a-ground.

The Ship is Bilged; that is, struck off some of her Keel, Timber, or bottom Planks on a Rock or an Anchor, and springs a Leak.

A Binnacle; that wherein the Compass stands.

A Bitter; a turn of a Cable about the Bitts.

The Bitts; Two great Square Pieces of Timber, to which the Cables are fasten'd, when the Ship rides at Anchor.

A Boom; a long Pole us'd to spread out the Clue of the scudding Sail, &c.

Board and Beard; a Term used when Two Ships come so near as to touch one another.

To make a-Board or Board it up, is to turn to Windward.

To break Bulk, is to open the Hold, and take out Goods thence.

C.

Creening, is heaving a Ship down on one Side, while they Trim and Caulk the other.

To Chase, is to pursue a Ship; and the Ship so pursued is called the Chase.

To Cund or Cunn, is to direct or guide; and to Cunn a Ship, is to direct the person at the Helm how to steer her. If the Ship go before the Wind, Quartering or Large, then he who Cuns the Ship, uses these Terms to him at Helm, Steady.—Steady, Starboard, Port (or Larboard) Helm, a Midships. Starboard, is to put the Helm to the Starboard (or Right) Side to make the Ship go to the Larboard (or Left,) for the Ship always sails contrary to the Helm. In keeping the Ship near the Wind, (when close haul'd) these Terms are us'd, Loof, Loof, keep your Loof, Fall not off, Veer no more, Keep her to touch the Wind, Have a care of the Lee-latch. To make her go more Large, or from the Wind, they say, Ease the Helm, No near, Bear up: And when the Ship is Full and By, as near as she will lie with her Sails full, they say, Thus,—Thus, keep her thus.

D.

Dead Water; the Eddy-Water at the Stern of the Ship.

To D. Scudbogue, is to go out of the Mouth of a Strait or Gulf.

The Deck is flush fore and aft; that is, laid from Stem to Stern without any Falls or Risings.

E.

END for End; a Term us'd when a Rope runs all out of the Block, so that it is unreely'd; as when a Cable (or Hawser) runs all out at the Hawse, we say, *The Cable or Hawser is run out End for End.*

F.

A *Pack*, is one Circle of any Rope or Cable, quoil'd up round.

To Farthel or Furl a Sail, is to wrap it up close together, and bind it (with flat-plated Strings, call'd Caskets,) fast to the Yard.

To Fish a Mast or Yard, is to fasten a piece of Timber or Plank to the Mast or Yard, to strengthen it; which Plank, &c. is called a *Fish*.

To Free the Boat or Ship, is to Bale, or Pump the Water out.

G.

THE Ship's Gauge, is so many Foot as she sinks in the Water; or to speak more Seaman-like, so many Foot of Water as she draws.

Weather Gauge, is when one Ship is to the Windward of another.

A Loom Gale, a little Wind.

The Ship Grips; that is, turns her Head more to the Wind than she should.

H.

TO *Hale*, is the same as to pull.

To over-hale, is when a Rope is not slack enough, to make it more slack.

To Hail a Ship, is to call to her Company to know whether they are bound, &c. and is done after this manner, *Hô, the Ship!* or only *Hôa*; to which they answer *Hâe*. Also to salute a Ship with Trumpets, or the like, is called *Hailing*.

Fresh the Hawse; a Term used when the part of the Cable that lies in the Hawse is fretted or chafed, and they would have more Cable veer'd out, that another part of it may rest in the Hawse. When Two Cables that come through two several Hawse-Holes are twisted, the untwisting them, is called clearing the Hawse.

Thwarts the Hawse, and *Rides upon the Hawse*, are Terms used, when a Ship lies Thwart or Cross, or with her Stern just before another Ship's Hawse.

Hawfs, are the great Holes under the Head of the Ship, thro' which the Cables run when she lies at Anchor.

The Ship Heels; that is, inclines more to one side than th' other; as, *she Heels to Starboard*, that is, turns up her Larboard side, to lie down on her Starboard: If on the other side, we say, *she Heels to Port*.

To Hitch, is to catch hold.

The Hold of a Ship, is that Part betwixt the Lower Deck and Keel-son, where all Goods, Stores and Victuals do lie.

Rampidge of the Hold, is used for removing or clearing the Goods and Things in the Hold.

To Heise or Hoist, is to hale or lift up; as, *Hoist in the Water*, *Hoist up the Yards*, &c.

Hulling; when a Ship at Sea, and by stress of Weather, or otherwise, takes in all her Sails, she is said to Hull.

L.

THE *Ship Labours*; that is, rowls and tumbles much.

Land-fall, is a Term used when we expect to see Land; as, *We have a good Land-fall*; that is, made Land (or saw Land) according to our Reckoning.

Land-locked, is when the Sea lies round about us, so that no Point lies open to the Sea.

Land to; a Ship is said to lie Land-to, when she is at so great a distance, as only just to discern the Land.

Lash, is to bind fast.

Launch, to put out; but generally us'd at Sea in a Negative Sense; as, when a Yard, &c. is hoisted, or hove by the Capston high enough, they usually call aloud, *Launch hœ!* That is, Hoise no more.

To lay the Land, is to lose sight of it.

The Lee-shore, is that Shore against which the Wind blows.

Have a care of the Lee-latch; that is, take heed the Ship go not too much to Leeward.

A Ship lies by the Lee; that is, has all her Sails lying flat against the Masts and Shrouds.

M.

MIZEN-sail, hath several Words peculiar to it; as, *set the Mizzen*; that is, hale the Sail out, and the Sheet aft. *Change the Mizzen*; that is, bring the Yard to the other side of the Mast. *Spack the Mizzen*; that is, put the Yard right up, and down by the Mast. *Spell the Mizzen*; that is, let go the Sheet, and peek it up.

To Moor a Ship, is to lay out her Anchors, in such a manner, as is most convenient for her to ride by safely.

N. Neap-

N.

N *Neap-Tides*, are the Tides when the Moon is in the Second and last Quarter; and they are neither so high nor so low, nor so swift as the Spring-Tides.

A Ship is be-neaped, a Term us'd, when the Water does not flow high enough to bring a Ship from off the Ground, or out of a Dock, or over a Bar.

O.

T *HE Offing*, that is, fromward the Shore, or out into the Sea; as *the Ship stands for the Offing*, that is, sails from the Shore into the Sea: Also when a Ship keeps the Middle of the Channel, and comes not near the Shore, she is said to *keep in the Offing*.

P.

T *O Parcel a Seam*, is (after the Seam is caulked, to lay over it a narrow Piece of Canvas, and pour thereon hot Pitch and Tar.

To pay a Seam, &c. is to lay hot Pitch and Tar on (after Caulking) without Canvas.

To ride a-peak, is when the Fore and Main-Yard are ropt up, or so order'd, that they make with the Masts, as it were the Figure of *St. Andrew's Cross*.

To Purchase, in a Ship, bears the same Sence as to draw many times, as, *The Captain purchases apace*, that is, draws in the Cable a-pace.

Q.

Q *uarter-Winds*, are when the Wind comes in abaft the Main-Mast Shrouds, even with the Quarter.

A Quoil, is a Rope or Cable laid up round, one Fack or Circle over another; and the laying of the said Facks one on another is called *Quoiling*.

R.

A *Reach*, is the Distance between any Two Points of Land, that lie in a Right Line one from another.

To Reeve, is to put a Rope through a Block, and to pull a Rope out of a Block, is called *unreeving the Rope*.

To Ride; when a Ship's Anchors hold her fast, so that she does not drive with Wind or Tide, she is said to ride at Anchor.

To ride athwart, is to ride with the Ship's side to the Tide.

To Ride betwixt Wind and Tide, is when the Wind and Tide are contrary and have equal Strength.

To ride Hawse full, is when in a Rough Sea, the Water breaks into the Hawse Holes.

A Road, is any Place near the Land, where Ships may ride at Anchor; and a Ship riding there, is called a *Roader*.

Rewse in, (that is, Haul in) proper only to the Cable or Hawser, and is used when the Cable or Hawser is slack, to make it tight or strait.

S.

A *Sail*, besides its proper Signification, (belonging to the several Yards, from which it takes its various Names, as, *Main sail*, &c.) it signifies also a Ship, as when we descry or spy a Ship at Sea, we cry out, *A Sail!* *A Sail!* Likewise if we speak of a Fleet (or a Number of Ships together) we say, *The Fleet consisted of 40 or 50 Sail*, and not of 40 or 50 Ships.

To Serve a Rope, is to wind spun Yarn about it, (with a Mallet for that purpose) to keep it from fretting out.

To Seaze, is to make fast or bind.

The Ship heels; that is, when on a sudden she lies down on her side, and tumbles from one side to the other.

The Ship sends; that is, her Head and Stern falls deep in the hollow of the Sea.

To settle a Deck, is to lay it lower.

The Ship is sewed; that is, the Water is gone from her.

The Ship bears; that is, goes in and out, and not right forward.

To sound, is to try with a Hand or Deep Sea Line and Lead, how deep the Water is.

The Ship hath spent her Masts; that is, her Masts have been broke by foul Weather; but if a Ship lose her Masts in Fight, we say, *Her Masts were shot by the Board*.

The Sail is split; that is, blown to pieces.

The Ship spoons; that is, goes right before the Wind without any Sails.

Spring-Tides, are the Tides at New and Full Moon, which Flow highest, Ebb lowest, and Run strongest.

The Bow-sprit steers; that is, stands too upright.

Steering, is likewise us'd by Mariners, when they stow Cotton or Wool, which being forc'd into small Vacancies in the Hold, with Screws, is called *steering* of Cotton or Wool.

T.

T *ACK the Ship*, or *Tack about*; that is, bring the Ship's Head about to lie the other Way.

Talle

Talle aft the Sheets, a Term used for halling aft the Sheets of the Main or Fore Sail.

A windward Tide, when the Tide runs against the Wind.

A Leeward Tide, when the Wind and Tide go both one Way.

A Tide gate, where the Tide runs strong.

To Tide it up, is to go with Tide against the Wind; and when the Tide is done, and alters, to lie at Anchor till it serveth again.

It flows Tide and half Tide; that is, it will be High Water sooner by three Hours at the Shore than in the Offing.

To Tow, is to drag a Ship, Boat, or any thing after the Ship.

The Traverse, is the Ship's Way in 24 hours, upon the shifting of Winds.

V.

TO *Veer*, is to let out; as, *Veer more Cable or Rope*, *Veer more Sheet*.

W.

THE *Ship is Walt*; that is, wants Ballast.

To Weather a Ship, is to go to Windward of her.

To Wind a Ship, is to bring her Head round about.

How Winds (or Capes) the Ship? That is, Upon what Point of the Compass does she lie with her Head?

To Would, is to bind Ropes about the Mast, or the like, to keep on a Fish to strengthen it.

Y.

THE *Ship Yaws*; that is, it goes in and out, and does not steer steady.

To Work a Ship at Sea, in the proper Sea-Phrases, and to manage her in Fight.

The Wind is Fair.

THE Wind is fair, tho' but a little; it comes well, as if it would stand: therefore up 2 or 3 hands, and loose the Fore-top-sail in the Top: Hoist the Colours, Unmoor the Ship, and heave up the Anchors. Haul home the Fore and Main top-sail Sheets; loose the Fore-sail and Mizzen in the Brails — Come, my Hearts, heave up the Anchor (that we may have a good Prize :) Heave away cheerly: Come, who says Amen? One and all. O brave Hearts, the Anchor is a Peek: Hoist the Fore and Main top sails; the Anchor is a-Weigh: Let fall the Fore sail, and Haul the Sheets aft:

ast : Up, and loose the Main-sail, and set him ; Cat and Fish the Anchor ; mind your Steerage, Right the Helm ; Seddy, steddyy. — The Ship is wore ; loose Sprit-sail, and Sprit-sail-top-sail. A brave Gale ; bring the Fore-tack to the Cat-Head, with a Paserebo ; and trim our Sails quartering : Loose Top gallant sails, and hoise up our small Sails ; heave out the Mizzen top sail, and set him. Now we are clear of the Land, and the Wind like to stand : Hoise in the Boats before it is too much Sea ; haul up the Main sail and Fore sail, and haul down your small Sails. — A Lee the Helm handsomely, and bring the Ship to easily, that she may not stay : Brace the Foretop Sail to the Mast : Pass Ropes, for the Boat's on the Lee side ; and be ready to clap on your Tackles, and Hoist them in ; stow them fast. — Put the Helm a Weather, fill the Fore top sail. Get the Fore tack to the Cat head again ; and haul ast the Fore sheet, and trim the Sails quartering as before : Let fall the Main sail, haul ast the Main sheets. — Hoist up the Top gallant sails, set the Sprit sail sprit sail, Top sail, and Main mizen. (Foretop mast main) Top mast stay sails, and the other small Sails : Come, rig out the Steering sail booms, and get up our Steering sails ; that we may make the best of our Way to our Cape, (or Port.) Clear your Ropes ; and now we have Sea-Room enough, stow your Anchors, and unbend the Cables ; get the Bucklers on the Hawse holes ; Cork in the Lower-Deck ports. — We lay the Land a pace, and make great Way thro' the Water. How bears the Point of Land (our Farewel Cape ?) N. b. W. about 7 Leagues distant ; ast heave the Log ; How many Knots does she run ? 9 Knots and $\frac{1}{2}$; set it down on the Log Board, with the Course steered ; as also, the Bearings and Distance from Land ; Mind the Compass and steerage ; How wind ye ? S. W. b. W. — Keep her away on her Course, W. S. W. so Steddy, — steddy ; settle the Watch and mind the Sails, &c.

Thus you have a gallant Ship, under all her Sails and Canvass, in her swiftest way of sailing upon the Sea. Now let us have her right before the Wind.

Right afore the Wind, and a fresh Gale.

THE Wind is veered right ast, take in your Fore and Fore top sail steering sails, and Fore and Main top sail stay-sails ; for they are becalm'd by the After sails, and will only beat out : The Wind blows a fresh Gale ; round ast the Fore and Main sheets, square the Yards, take in the Steering sails, and Top gallant sails, in Sprit sail sprit sail, and Mi-

Mizen top sails. Let go the Sheets, clew them up, and hand them.

Thus you have all the small Sails in and furled, when it blows too hard to bear them.

The Wind veereth forward and scanteth.

THE Wind scanteth, veer out some of your Fore and Main sheets, and Sprit sail sheets, and let go your Weather-braces; Top the Sprit sail Yard. — The Wind still veereth forward; get aboard the Fore and Main tacks; cast off your Weather sheets and Braces. — The Sails are in the Wind; haul aft the Fore and Main sheets: The Wind is Sharp, haul forward the Main Bow line and Fore Bow line; and haul up the Fore top sail and Main top sail bow lines, and set in the Lee braces: Trim sharp, and keep her full and by, as near as she will lie.

Thus have you all Sails trim'd sharp, and the Ship by (or upon) a Wind.

The Wind blows fresh on sniking.

THE Wind begins to blow fresh, and it looks dirty to Windward; Come reef the Top sails close, taking in all the Reefs; slide down the Shifting Back stays, One third of the Masts lower. Hoist the Top sails; let in the Lee braces; the Wind blows harder, settle the Fore and Main top sails two thirds of the Mast down. — It is more Wind, stand by the Lee sheets, and Top sails hallyards; haul down both Top sails, close; stand by, take in the Fore top sail: Let go the Fore top bow line and Lee braces; let go the Lee sheet, set in your Weather brace; spill the Sail, haul up the Top sail clew lines; square the Yard, haul up the Bunt lines and Leech lines; and bear a Hand, and furl the Sail. — Come, stand by again to hand the Main top sail. — Come, take in the Main top sail; let go the Main top bow line, and Lee brace; let go the Lee sheet, set in your Weather brace; spill the Sail, haul home the Top sail clew line; and haul up the Bunt lines and Leech lines, and bear a Hand; furl the Sail.

Now the Top sails are furl'd and you have the Ship in all her Low sails or Courses.

It bloweth a Storm.

It is like to over blow, stand by to haul up the Fore sail; cast

cast off the Top sail sheets, Clew garnets, Leech lines, Bunt lines; stand by the Sheer and Brace; haul up the Fore sail; let go the Fore sheet, raise the Fore tack; haul up the Clew garnets, Bunt lines and Leech lines; lower the Yard, and furl the Sails. — Here is like to be much Wind; see that your Main, (Jeers) and Hallyards be clear; and all the rest of your Geer clear and cast off: Is it all clear? Yea, yea: Come, lower the Main yard; haul down upon your down-haul: Now the Yard is down, haul up the Clew garnets, Lifts, Leech lines, Bunt lines; and furl the Sail fast; and furl the Yards, that they may not traverse and gall.

Thus have you the Ship a-cry, under a Mizzen

A very hollow grown Sea

WE make Foul Weather; Gunner, look that the Guns be well lashed, and their Trucks quoin'd. — Come aft, haul the Mizzen up. The Ship lies very broad off in the Trough of the Sea; see the Hatchcs well secur'd, and the Tarpaulins nail'd over them. — It is better Spooning before the Sea, than trying or hulling: Come, my Hearts, Reef the Fore sail and set him; haul aft the Fore sheet, put the Helm hard a Weather; mind at Helm what is said to you: The Ship wares bravely, steady, steady; she is before it. — The Fore sail is split to pieces; forward, my Hearts: Haul down the Yard, and get the Sail into the Ship, and unbend all things clear of it. — Starboard, hard up, right your Helm, Port, Port, Port hard; get able Men to the Helm. — A very fierce Storm; the Sea breaks, strange and dangerous. — The Ship has broach'd too, and the Sea hath fill'd us full and full upon Deck; but there is but little gone down the Hold. Come, sound the Well, try the Pump; spell and spell: She makes but little Water. Come, my Hearts, let's try to Ware the Ship again; our Canvass will not hold the Wind. — Well then, get up as many Men as can well stand in the Weather Fore shrouds, hard a Weather your Helm; hard up. — The Ship wares round, so right the Helm; steady, steady, mind the Helm carefully: Shall we get down our Top masts? No, let all stand; she scuds before the Sea very well: The Top masts being aloft, the Ship is the wholesomest; and makes better way through the Sea, seeing we have Sea-room.

Thus you see the Ship handled in fair Weather and foul, by and large: Now let us see how we can turn to Windward.

The Storm is over, let us turn to Windward.

TH*E* Storm is over, set Fore-sail and Main-sail, bring the Ship too; set the Mizzen, the Main-top-sail, the Fore-top-sail, and Mizzen-top-sail; our Course is W.S.W. the Wind is at S. get the Larboard Tacks aboard: cast off the Weather-braces and Lifts; set in the Lee-braces, and hale aft the Sheets; haul forward the Bow-lines, haul the Mizzen-tack over to Windward; keep her full and by as near as she will lie: How Wind ye? W. a quade Wind: No near, hard, no near; the Wind veereth to the Westward still: How Wind you? N.N.E. The Wind will be Northerly, make ready to go about; we shall lie our Course the other way: No-near, give the Ship way, that she may stay; Ready, ready, a-Lee the Helm; let go the Fore-top-bow-line, veer out the Fore-sheet handsomely; cast off the Lee-braces, of your Fore-sail and Fore-top-sail; brace in upon your Weather-braces: Tend the Ship brace a-back; the Fore sails is a-back-stays; (the Wind is a head;) haul Main-sail, haul; let rise the Main-tack; cast off the Star-board-braces; let go the Main-bow-line, and Main-top-bow-line; brace about the Yard, haul forward the (Starboard) Main, and Main-top-bow-line, Mizzen-top-sail-bow-line; brace the Cross-jack yard, set in the Lee-braces of the Main-yard-main-top-sail, and Mizzen-top-sail-yard; get the Main-tack close down in the Chels-tree; haul the Main-sheet close aft; haul off all, haul—Get aboard the Fore-tack, let go the Fore-bow-line, Fore-tack; let go the Fore-bow-line, Fore-top-bow-line; set in the Lee-braces of the Fore yard, and Fore top-sail yard; haul aft the Fore sheet; haul tight the Main Bow-line, and Main-top Bow-line; shift the Mizzen tack, haul tight the Fore Bow line, Fore top Bow line; and set in the Lee braces fore and aft; and keep her as near as she will lie: So, thus, thus, come no nearer.—Fall not off, Loof, Loof; How wind you? W. N. W. Thus ware, no more, keep her full: How wind you? N. W. The Wind is at N.N.E. Keep her away her Course, W.S.W. Cast off the Lee braces and Weather-bow lines, and set in your Weather braces: Veer out the Main Sheet and Fore Sheet; loose the Sprit-sail, and Sprit-sail top sail, and Top-gallant sails, and hoist them up; set the Stay sails, and Small sails; the Wind veers aft still; the Wind is quartering; haul aft the Starboard Fore-sheet; let rise the Fore tack, bring it down to the Car-head with a Pass-a-rée; stiddy in your Weather brace; the Wind stands a brave Gale, and we make good way thro' the Water.

Thus

Thus you have the Ship as at the first steering, under all her Canvas, Quarter Wind: She hath been wrought in all manner of Weather and all sorts of Winds: Therefore shall draw to a Conclusion of this Section, with a Man of War in Chase, and taking of her Prize.

The cruising Man of War in her Station.

NOW we are in our Station, and a good Latitude; hand your Top sails, and furl your Fore sail and Main sail; and brail up the Mizzen, and let her lie a Hull, until Fortune appear in our Horizon: Up aloft, a Man to the Main top mast head, and look well out, if you can see any Ships that have been nipp'd with the last Northerly Winds. — A Sail, a Sail: Where? Fair by us. How stands she? To the Eastward; and is about Two Points upon our Lee bow, and hath her Larboard Tacks aboard: O, then she lies close by a Wind. — We see her upon the Decks plainly: A Couple of good Men to the Helm; up and loose the Fore sail, Main sail, and Mizzen; get the Larboard tacks aboard; heave out the Fore top-sail, Main top sail, and Mizzen top sail; loose the Spirit sail, keep her as near as she will lie; haul aft the Sheers, and haul up your Bow-lines right. Do you see your Chase? Yea, Yea: How wind you? E. N. E. Then the Wind is at N. hoise up your Top sails, as high as you can; come, set the Spirit sails, Spirit sail top sail, Flying Jibb, Top gallant sails, Main and Mizzen stay sails, Main and Fore top sail stay sails, and the Top gallant stay sails. — It blows a brave Chasing Gale; the Ship makes brave way through the Water; we raise her apace; if she keep her Course we shall be up with her in 3 or 4 Glasses; no near, keep the Chase open with the Lee latch of the Fore sail; so keep her thus. — Come aft all Hands, the Ship will steer the better, when you sit all quiet by her Small sails, for she is too much by the Head: The Chase is a lusty brave Ship; so much the better, she hath the more Goods in her Hold: the Ship hath a great many Guns; no matter, we can match her. — No near, the Chase is about; come fetch her Wake, and we will be about after her; we sail far better than she. — We have her Wake, a Lee the Helm; ease off the Fore sheet, handsomely; every Man stand handsomely to his Business, and mind the Bow-lines and Braces, Tack and Sheers. — The Wind's a Head; haul Main-sail, haul; let go Main bow line, Top bow line, Top gallant bow line; get aboard the Main tack; haul aft the Main-sheet; brace the Main-

Main yard, Main-top-sail and Main top gallant yard, Cross-tack, and Mizzen-top-sail-yard; shift the Mizzen tack — Haul off all, haul; shift the Helm, bring her too; haul the Fore sheet close aft, set in the Lee-Braces; haul right the Bow-lines. The Chase keeps close upon a Wind; keep her open under our Lee. — Gunner, see that you have all Things in readiness, and that our Guns be clear; let nothing pester our Decks. — Get up all the Hammocks, and stow them in the Nettings of the Quarter-Deck, Fore Castle, and on the Gun-wall in the Wastle; down with all the Bulk-Heads, &c. that may hinder, or hurt us with Splinters. — Gunner, is all our Military Geer ready? Is there store of Cartridges of each sort, ready? all manner of Shot in the Garlands between the Guns, and at the Main mast? Are there Rammers, Sponges, Ladles, Priming Irons, Horns, Linstocks, Wads, Swabs, and Water in the Tubs, at their several Quarters, sufficient for them? Be sure that none of our Guns be cloy'd; and when we are in Fight, be sure to load our Guns with Cross bar and Langrel: always observing to give Fire when the Word is given. — See that the Blunderbusses, Musketoons, Firelocks, Pistols, Swords, Cut-lashes, Pole Axes, Half-Pikes and Javelins be in readiness; and all our Cartouch Boxes and Bandoleers, fill'd and furnish'd with Powder and Shot; see that our Patereroes in the Tops, with the Murtherers and Stock Flowers, have their Chambers fill'd with good Powder, and Bags of Small shot to load them; that if we should be laid aboard, we might clear our Decks. — Lieutenants, call over the Quarter List, and see every Man and Boy, at their Gun's Small Arms; and in the Tops at their several Quarters. — Observe when we are near the Chase, in Fight to load our Guns with Double-head round and Partridge Shot, and to Fire our small Arms. The Chase pays away more room. — Hard a Weather, veer out some of the Main sheet, and Fore sheet, cast off the Larboard braces; steady, steady, Right the Helm; keep her thus; well steer'd, The Chase goes away room, her Sheets are both aft; she is right before the Wind; Starboard hard; let rise the Main tack, let rise the Fore tack; haul aft the Fore sheet. — We have a Stern Chase, but we shall be up with her presently, for we fetch upon her Head going. Hoist our Colours, spread the Wast Cloths and Top Armour. The Chase hauls up her Main sail and furls it; she puts abroad her Wast Cloths; she will Fight us! Come, my Hearts, up and furl our Main sail, sling our Main yard with the Top-Chains, sling our Fore yard. — She will fight us before the Wind; I see she is full of Men; it is a Hop Ship

Ship, but Deep and Foul; she is a 60 Gun Ship, and full of Men; (but we shall match her, altho' we have but 50 Guns.) Come, cheerly my brave Hearts, it is a Prize worth fighting for: The Chase takes in her Small sail; up and take in our Top gallant sails, Sprit sail and Sprit sail top sail; get the Sprit sail yard along Ship under the Bow sprit. — She puts abroad her Colours, they are White; they are *French* Colours, no Force; Boys, ours are *St. George's* — Call all Hands aloft. Come up aloft all Hands: They are all up, Captain.

The Captain's Speech.

GENTLEMEN, We are here employ'd and maintain'd by his Majesty King *George*, and our Country; to do our Endeavours to keep the Sea from Piracy and Robbers, and his Majesty's Enemies; and it is our Fortune to meet this Ship at this time: Therefore, I desire you in his Majesty's Name, and for the sake of our Country, and the Honour of our *English* Nation, and our selves, that every Man behave himself Couragious, like *Englishmen*; and not have the least shew of a Coward: But observe the Words of Command, and do his utmost Endeavour. Into God's Hand we commit our Cause, and our selves; so every Man to his Quarter, and shew his Courage, and God be with us, and grant us the Victory.

She settles her Top sails, we are within shot; let all our Guns be loose in the Tackles, and the Ports all knock'd open, that we may be ready to run out our Guns when the Word is given; up noise of Trumpets and Hail our Prize; she answereth again with her Trumpet; Hold fast Gunner, do not Fire till we hail them with our speaking Trumpet; Port edge towards him; so, now we are fairly along side of him, and within Musket shot: Come, my brave Men, run out your Guns, and give him a Broadside, a Volley of small Arms, and a Huzza. — Well done, my Hearts. — He returns our Compliment, by firing his Broadside upon us. — What cheer, my Hearts, is all well betwixt Decks? Yea, yea, only he has rak'd us through and through; no Force, it is his Turn next; but give not Fire again, till we are within Pistol shot: Port edge towards him, he plies his Small shot. Come, Boys, Load and fire our small Arms briskly at him: Hold fast Gunner; Port, Right your Helm, we will run up his side; Starboard a little, Fire a Broadside, Gunner. — That was well done; this Broadside hath made their Decks thin of Men, but his Small shot at first did gaul us. — Clap in some Case or Partridge-shot in the Guns. — You are now a Loading: Brace too the Fore top sail, that we may not shoot

shoot a Head of him ; he lies broad off to the Southward, to bring his other Broadside to bear upon us : Starboard, hard ; get aboard the Larboard Fore tack, trim your Top sails ; run out your Larboard Guns : He fires his Starboard Broadside upon us ; he pours in his Small shot : Starboard, give not Fire until he fall off, that the Prize may receive our full Broadside ; steddly, Port a little : Fire a Broadside. His Fore mast is by the Board ; this last Broadside hath done great Execution ; Huzza, cheerly my Mates, the Day will be ours, he is shot a Head ; he bears up before the Wind, to stop his Leaks : Keep her thus, well steer'd ; Port, Port hard ; bear up before the Wind, that we may give him our Starboard Broadside : Gunner, see that the Guns be loaded with Doublehead round and Case shot : Yea, yea, Port, make ready to board him, have your Lashers and Grapplings ready, and able Men with them : Edge towards him ; when you give Fire, bring your Guns to bear amongst his Men, with the Case shot ; well steer'd, we are close on Board ; give Fire again : Starboard, well done my Hearts ; they lie Heads and Points aboard the Prize ; come, board him bravely : Enter, enter, are you lash'd fast ? Yea, yea, we will have him before we go here hence. — Cut up the Decks ; ply your Hand Grenadoes. — He cries out Quarter ! Quarter for our Lives, and we will yield up Ship and Goods. — Good Quarter is granted, provided you will lay down all your Arms, open the Hatches, haul down all your Sails, and furl them ; loose the Latchings, we will sheer off our Ship, and hoist out our Boats : If you offer to make any Sail, or Fire again, expect no Quarter for your Lives. — Go aboard him with our Boats ; and send aboard the Captain, Lieutenant, Master and Mates, with as many more as our Boats will carry.

So will we leave the Man of War to his Prize and Plunder, and to secure his Prisoners ; and shall conclude this Section with Ovid, when he sail'd in the Ionian Streights.

NOTHING but Waves we view, in Sea where Ships do float ;
And Dangers lie, huge Whales, and all Fish play :
Above our Heads, Heaven's Star-embroider'd Coat ;
Whose Vault contains Two Eyes for Night and Day,
Far from the Main, or any Marine Coast,
Twixt Borean Blasts, and Billows we are toss'd.
(If OVID, in that Streight of Ionian Deep,
Was toss'd so hard ; much more are we, on Seas
Of larger Bounds ; where Staff and Compass keep
Their strict Observance : Yet in this Unease

Of Tacking Boards, we so the Way make short;
 That still our Course draws nearer to our Port.)
 Between the Sea and Silver spangled Sky,
 We rowling climb, then hurling fall beneath :
 Our Way is Serpent like, in Meads which lie,
 That bow like Grass, but never make a Path ;
 But fitter like Young Maids and Youths together ;
 Run here and there, all where, and none knows whither ?
 Our Way we know, and yet unknown to other ;
 And whilst mis-known to us, before we dive,
 The Hand and Compass, that governs the Rudder,
 Do often err ; altho' the Pilots strive
 With Chart and Compass : Yet our Reck'nings fall
 Too narrow, short, too high, too wide, too small.
 To discon this Remark, when we set Land,
 Some this, some that do guess ; this Hill, that Cape.
 For some Hours our Skill in suspense stand ;
 Terming this Shore, that Head-land points the Map ;
 Which when mistook, this forg'd Excuse goes clear,
O such and such a Land it first did 'pear.
 In all which Strife, stress'd Sailors have the Pain ;
 By drudging, pulling, haling, standing to it :
 In Cold and Rain, both dry and wet, they strain
 Themselves, and toyl ; none else but they must do it ;
 Both *Prow* and *Poop* do answer to the *Helm* :
 The *Steersman* sings ; no Grief his Joy can whelm.
 By Night our Watch we set, by Day our Sight ;
 And make more sail, if Pirates do appear ;
 We rest resolv'd. 'Tis Force makes Cowards fight ;
 Tho' none more dare, than they that have most Fear.
 It's *Courage* makes us Rash, and *Wisdom* Cold :
 Yet Wise Men, Stout, and Strong, grow Lion-bold.
 The Wise Man knows his Wisdom how to use ;
 The Artificer, what Art 'tis best to chuse.
 'Tis a True Saying, and approved long,
The Wise Man is more Worthy than the Strong :
 The Field he Tills, the City he can guide ;
 And for the Ships in *Tempests* will provide.

For defensive Sea fighting, see Park's Art of Sea fighting in Mer-
chant Ships, &c.



Of the Sea or Ocean.

THE continual Motion and Agitation, Flux and Reflux of the Sea, is of great Use in Navigation; and the Seas thereby purge themselves: By which they are kept from Putrefaction; like a Fountain it cleanses it self. *Isa. 57. 20. It cannot rest, but casts up Mire and Dirt;* whereas Lakes and Ponds, whose Waters are standing and dead, corrupt and stink. And it is observ'd by Seamen, that in the Southern Parts of the World, where the Sea is more calm and settled, it is more corrupt and unfit for Use. So is the Sea of Sodom called *The Dead*: In which, 'tis reported, that the Birds flying over it, drop down Dead.

*The Seas within their Bounds the Lord contains;
He also Men and Devil holds in Chains.*

It is a wonderful Work of the All wise Creator, to limit and bound such a vast and furious Creature as the Sea: Which, according to the Judgment of the Learned, is in many Places higher than the Earth; as in *Holland, &c.* And that it hath a Propension to over-flow it, is evident, both from its Nature and Motion: Were it not that the Omnipotent and Omniscient GOD, has laid his Law upon it. And this is a Work where the Lord glories, and will be admir'd: *Psal. 104. 9. Thou hast set a bound that they may not pass over, that they turn not again to cover the Earth;* which it is clear they would do, were they not thus limited. So *Job 38. 8, 10, 11. Who shut up the Sea with Doors, when it break forth as if it had issued of the Womb? I brake up for it my decreed place, and set Bars and Doors;* and said, *Hitherto shalt thou come, but no further;* and here shall thy proud Waves be staid.

*In the vast Ocean Seamen may descry
God's boundless Mercy and Eternity.*

The Ocean is of a vast Extent and Depth, though supposedly measurable; not to be sounded by Man in many Places. It compasseth about the whole Earth, which in the Account of Geographers, is 26293 $\frac{1}{4}$ Miles, and its Diameter 8369 English Miles: The Surface of the Earth contains

220048209 $\frac{1}{2}$ of Square English Miles; containing about 76 Millions of Millions of Acres: And its Solidity is 306930160535 $\frac{1}{2}$ of Cubick English Miles, which is the Solid Content of the Terraqueous Globe.) Yet the Ocean invirons it on every Side; (Psal. 104. 25. Job 11. 9.) suitable to which is that of the Poet:

*Tum freta diffudit, rapidisve tumescere ventis
Iussit & ambita circumdare littora terra.* Ovid.

He spread the Seas, which then he did command
To swell with Winds, and compass round the Land.

And for its Depth, who can discover it? The Sea, in Scripture is called *the Deep*, Job 38. 30. *The great Deep*, Gen. 7. 11. The gathering together of the Waters into one Place, Gen. 1. 9. If the greatest Mountains were cast into it, it would appear no more than the Head of a small Pin in a Tun of Water.

The Waters of the Sea in themselves, are Brackish, Salt, and Unpleasant: Yet, being exhal'd by the Sun and condens'd into Clouds, they fall down in pleasant Fresh Showers: Or if drain'd through the Earth, their Property is thereby alter'd; and that which was so salt in the Sea, becomes exceeding sweet and pleasant in the Spring. This we find by constant Experience, the sweetest Chrystal Spring came from the Sea, Eccles. 1. 7.

Of the Nature and Qualities of the principal Winds.

“THE Wind, saith Aristotle, is an Exhalation Hot and Dry, engendred in the Bowels of the Earth; and being gotten out, is carried fadelong upon the Face of the Earth.” The North Wind, called *Septentrio*, *Aquilo*, or *Aparrhas*, is extremely Cold and Dry, prohibiting Rain: It preserveth Health by cleansing the Air of all Pestiferous Infections; but it causeth Dry Colds, and hurteth the Fruits and Flowers of the Earth.

The N. E. b. N. called *Aquilo* or *Boreas*, is also Cold and Dry, without Rain: It hurteth the Flowers and Fruits of the Earth, and especially the Vines when they bud.

The N. E. b. E. called *Hellepontus* or *Cecias*, is Hot, drying up all Things.

The

The East-Wind, called *Eurus*, *Subsolanus*, or *Apeliotes*, is Hot and Dry, Temperate, Sweet, Pure, Subtle and Healthful; and especially in the Morning when the Sun riseth, by whom it is made more Pure and Subtil, causing no Infection to Man's Body.

The E.S.E. called *Eurus* or *Vulturnus*, is also Hot and Dry: It bloweth loud, and therefore is call'd *Lucretius*, *Alcitouans*, *Vulturnus*.

The E.S.b.S. called *Eurus* or *Euronotus*, is Hot and Moist, and breedeth Clouds and Sicknefs.

The South-Wind called *Auster* or *Notus*, is Hot and Moist; breeding thick Clouds, great Rains. and pestiferous Air.

The S.W.b.S. called *Austro-Africus* or *Libonotus*, is temperately Hot; and yet, breedeth Rain and Sicknefs, as some write.

The S.W.b.W. named *Africus* or *Libs*, is Cold and Moist, causing Rain.

The West-Wind, called *Favonius* or *Zephyrus*, is temperately Hot and Moist, and wholesome in the Evening: It dissolveth Frost, Ice, and Snow, and maketh Flowers and Herbs to spring; and some write, that it causeth Thunder.

The W.N.W. called *Corus* or *Syrus*, is Cold and Moist, without any great rigour.

The N.W.b.N. called *Syrus* or *Trachias*, is Cold and Dry, of Earthly Nature, breeding Snow and Winds, and oft-times Storms and Tempests. Thus,

Through many Fears and Dangers Seamen run,
But all's forgotten when they do return.

Of which we have an Elegant and Lively Description, *Psal.* 107. 25, 26, 27. He commandeth, and raiseth the stormy winds, which lifteth up the waves of the Sea: They mount up to Heaven; they go down again to the Depths: Their Soul is melted because of the Trouble; they reel to and fro, they stagger like a drunken Man; they are at their wits end: Or, as it is in the Hebrew all Wisdom is swallowed up. Suitable to which, is that of the Poet:

*Reffor in incerto est, nec quid fugiatne petatur,
Invenit ambiguus ars stupet ipsi malis.*

Ovid.

The Pilot knows not what to chuse or flee;
Art. stands amaz'd in Ambiguity.

These dreadful Storms do at once discover to us the mighty Power of God in raising them; and his abundant Goodness

ness in preserving poor Creatures in them. First, The Power of God is graciously manifested in raising them: The Wind is one of the Lord's Wonders, *Psal. 107. 24. 29. He commandeth and raiseth the stormy Wind.* Yea, *Verse 18.* God appropriates it as a peculiar Work of his; *He causeth (his Wind to blow)* Hence he is said in Scripture to bring them forth of his Treasury: *Psal. 137. 7. There they are locked up and reserved;* not a Gull can break forth, till he command and call for it to go and execute his Pleasure: Yea, he is said to hold them *in his fist*, *Prov. 30. 4.* What is more incapable of holding than the Wind? Yet God holds it: Altho' it be a strong and terrible Creature, he controuls and rules it. Yea the Scripture sets forth God as *riding upon the Wings of the Wind*, *Psal. 18. 10.* It is a borrowed Speech from the manner of Men, when they would shew their Pomp and Greatness, *Ride upon some stately Horse or Chariot:* so the Lord, to manifest the Greatness of his Power, rides upon the Wings of the Wind, and will be admir'd in so terrible a Creature. And no less his glorious Power appears in remanding them, than in making them.

The Heathens ascribe this Power to their God *Aeolus*; but we know this is the Royalty and sole Prerogative of the true God, who made Heaven and Earth: It is he that makes the Storm a Calm, *Psal. 107. 29.* and it is he that shifts and changes it from Point to Point of the Compass, as he pleaseth; for he hath appointed them in their Circuits, *Eccles. 1. 6. The Wind goeth toward the South, and turneth about unto the North; it whirleth about continually, and returneth again according to his Circuits.* And as we should adore his Goodness in preserving Seamen (in a poor weak Vessel) in the height of all their Fury and Violence: Therefore I shall conclude this Discourse with a Poem out of that excellent Book of Mr. John Flavel's *Navigation spiritualiz'd*, P. 30. viz.

A Description of a Ship in a Storm and Distress.

THE Ship that now sails trim before the Wind,
E're the desir'd Port it gains, may find
A tedious Passage: Gentle Gales a while
Do fill its Sail; the flattering Seas do smile:
The Face of Heaven is bright; on every side
The wanton Porpoise tumbles on the Tide.
Into their Cabbins now the Seamen go,
And then out again, with *What Cheer* ho?
All on a sudden, dark'ned are the Skies,
The Lamp of Heaven obscur'd, the Winds do rise;

The

Waves swell like Mountains & Now their Courage flags.
 The Masts are sprung, the Sails are torn to Rags.
 The Vessel works for Life; anon, one cries,
The Main-mast's gone by th' Board: Another plies
 The Pump, until a third do strike them blank,
 With, *Sirs, prepare for Death w^h have sprung a Plank.*
 Now to their Knees they go, and on this wise,
 They beg for Mercy with their loudest Cries:
Lord, save us but this once, and thou shalt see
What Persons for the future we will be;
Our former Time's mis-spent; but with a Vow
We will engage, if thou wilt save us now,
To mend what is amiss. The gracious Lord,
 Inclind to Pity, takes them at their Word:
 The Winds into their Treasure he doth call;
 Rebukes the stormy Sea, and brings them all
 To their desired Haven: Once a-shore,
 And then their Vows are ne'er remember'd more.

Of the various Colours of the Sea.

THE Variety of Colours of the Sea-Water, at several Times chiefly depends upon the Wind and Weather, Deepness or Shoalness of the Sea, and the Reflection of the Light upon it. Its usual and most natural Colour, is a deep Green: But in Cloudy and Rainy Weather, the Surface of the Water appears Blackish; and sometimes of a deep Blue, according to the Colour of the Sky, and the great Depth of the Water. On Sands (or Shoals) upon the Tide of Flood, the Water is generally White; the Waves, by reason of the Shallows, meeting with Opposition, and breaking into Foam, till the Flood is well advanced. Sometimes the Water is of a perfect Azure Colour, the Sun shining bright upon it. Sometime the upper Part of the Waves appears Purplish, sometimes Reddish: Though in Shallow perchance it may receive this latter Tincture also from the Sands which lie under it; and so 'tis thought of the Red-Sea.

I have observ'd, when the Ship has been under sail, and the Wind has freshen'd, the Waves at the Head and Sides of the Ship, to appear with a Pale kind of Brightness: So have I seen at Night, by the Sides and Bow of the Ship, the Sea as it were a sparkling Flame: The same also is observable in a Boat's Rowing in the Night, by the Oars falling rough

roughly into the Water, seems as a continued Flame; which I ascribe rather to the Saline Particles of the Sea-Water, which were then put into a violent Agitation, than to the Spawn of Fish, as some of our Seamen imagine.



Natural Prognosticks of the Weather, deduced from Philosophical Aphorisms, and frequent Experience of Judicious Persons.

I. By the SUN.

IF the Sun look Pale, look for Rain; if Fair and Bright, Fair Weather; if Red, Wind.

If the Sun appear in the East, greater than it usually doth, it is a Sign of Rain.

The Sun rising Bright and Clear, signifieth a pleasant Day: If he rise Fiery Red, or shews Broad, as through a Mist, or has a Circle about him, expect Rain.

If the Sun drive the Clouds before him into the West, it signifieth Fair Weather: If at his rising there appear a Circle about him, and vanisheth away, equally, it betokeneth Fair Weather.

If at the Rising of the Sun, his Beams seem Red or Long, or encompassed with Red Clouds, it signifieth great Winds: If at his Rising there appear a thick Mist, or if it raineth in the Evening, it threatneth very foul Weather to follow: Also if the Sun-Beams be spotted either Green, Pale, or Black, or gathered to a Cloud it signifieth Rain.

If the Circle or Circles, about the Sun be clear, and of no Continuance, look for Fair Weather.

If there be many Circles, it signifieth Winds; the Redder they are, the more vehement Winds. If the Circles are here and there broken, and are Thick and Black, look for cold Wind or Snow: Or if the Sun settles behind a great Black Cloud, Rain follows.

If a Black Cloud appear, and about Sun-setting, it will Rain that Night or the Morning following. Or if He setteth Red, or Clear without a Cloud, it signifieth Fair Weather. If at his setting he be of divers Colours, or Clouds like Water, it threatens Rain: Or if it raineth in the Evening, Foul Weather will follow. If there appear Fiery Spots in the Sun at his Setting, much Wind will ensue.

II. By

Prognosticks of the Weather.

II. By the MOON.

If the Moon look Pale, look for Rain; if Fair and Bright, Fair Weather; if Red or Blushing, Storms of Wind will ensue.

If the Moon in the Third Day after her Change, or Three Days before her Full, or in the Midst of the Quarter, be found of pure Light, nothing compassing her, the Ends direct up, she promisseth Fair Weather; but bent to Red Colour, provoketh Winds, as aforelaid. The Moon somewhat Black or thick, provoketh Rain. When the Moon's Horns are blunt at its Rising, Three Days after the Change, it denotes rainy Weather for that Quarter; but the other Quarter seasonable Weather: Hence observe,

*As is the Fourth and Fifth Days Weather,
So's that Lunation altogether.*

And when the Moon is Five Days old, mark the Tip of her Horns; if they be blunt, it signifieth Rain; if sharp-pointed and pricking upwards, great Winds: If in the Fourth after her Change, she have a Red Circle about her, it signifieth Winds and Rain.

III. By the STARS.

THE obscuring of the smaller Stars foreshews Tempests. When Stars seem to shoot, Wind comes from that Quarter. If the Stars appear of much Light, and seem to be of more Bigness and Blazing than ordinary, it betokeneth great Winds and Moisture in that Part where they seem so; and in Winter great Frosts.

When dim Stars appear with long Fiery Tails, it threatneth Winds and great Drought; the more in Number, the greater will be the Effect.

If the Stars seem to shoot in divers Places, it signifieth divers Winds: If in all Places, Wind, Thunder, Lightning, and most tempestuous Weather.

Stars dull and hardly appearing, or seeming Dull and Large, and through Mists, betoken Rain.

IV. By the SKY and CLOUDS.

If the Sky be Red in the Morning, it is a sure Token of Wind or Rain to follow, or both in Squalls, &c. for the Vapours which cause that Redness, will soon be dissolv'd.

If a dark Cloud be at Sun-rising, in which the Sun is soon after hid ; it will dissolve it, and Rain will soon follow.

If a Cloud appear, and afterwards Vapours are seen to ascend up to it, it portends Rain.

If Mists come down from the Hills, or descend from the Sky, and settle in the Vallies, it promiseth Fair and Hot Weather : Also Mists ascending in the Evening from the Earth or Water, shew a Hot Day to follow.

Small scattering Clouds in the S. W. that fly high, and lie as it were in Ridges, and seem to move, engender Winds, and often produce Whirlwinds.

A hasty Shower of Rain falling, when the Wind has rag'd some Hours, soon allays it : If a Storm rise with the Sun, at going down of the Sun it will soon decline, and about Mid-night cease. If the Water ruckles much, and frequent Bubbles arise, the Storm is of a short Continuance.

Black Clouds flying from the East, signifie Rain at Night ; if from the West, Rain the next Day : If they fly low, and appear to settle on the Tops of Hills, it is a Sign of Cold Weather : If they be full-charg'd, and appear White, like Towers, Hail is at hand. If White Clouds appear in Winter, Two or Three Days together, at Sun-rising, it is a Sign of Cold and Snow ; but Black-Clouds signifie Rain. A Red Sky in the Evening, and a Grey Morning, is a Sign of a Fair Day. Mists falling of a Morning, in Spring or Harvest ; also Mists over Ponds or Waters in the Morning, shew Rain. If the Clouds fly swiftly in the Air, it signifies Rain from that part of the Heavens, especially from the North or South. If thick White Clouds, gathered together in many Places, like Flocks or Heaps of Wool, appear ; it is a Sign of Rain : But if thick dark Clouds, toward the North or West, near the Earth, presently Rain ; and if like Hills, a little above the Earth, Foul Weather is over. If Mists descend from the Hills, and settle in the Vallies, it is a Sign of Fair Hot Weather next Day ; or if White Mists arise from the Waters in the Evening.

V. By the RAINBOW.

THE natural Signification of the Rainbow, is to shew Rain past or to come.

The Rainbow appearing when it is Fair, is a Sign of Foul Weather ; but a Rainbow appearing after Rain, signifies Fair Weather : The Greener it appears, the more Rain ; the more Wind, if it appears Redder. If it shews very Light in the Blue Part, expect Fair Weather. If the Rainbow is seen before

before Noon, then the Rain is spent ; if at one One or Two Afternoon, the Rain is near. A Rainbow in the Morning, is a Sign of Wet, (unless there be Drought in the Air :) If it appear in the Evening, it is a Sign of Fair Weather, (unless the Air abound with Moisture.) A Rainbow at Night, opposite to the Moon, is a Sign of much Small Rain and Wind to follow. A Rainbow after long Rain, is Sign of Fair Weather, presently. If Two Rainbows appear together, it is a Sign of Rain within Two or Three Days.

Answers to the Questions in NAVIGATION, propos'd at the Beginning of this Appendix.

In Plain-Sailing.

- Q**UEST. I. Course S.W.b.S. $\frac{1}{2}$ W. nearest Dist. 91 $\frac{1}{2}$ l. Lat. 68 $\frac{1}{2}$ l.
 Quest. II. Course S.E. $\frac{1}{2}$ E. Dist. 370 l. Departure 296 l.
 Quest. III. Course S. 64° 28' W. Southing 52m Westing 108m.
 Quest. IV. Dist. 252, 1098 l. Lat. 208, 9752 l. Dep. 139, 691 l.
 Quest. V. Dist. 946 m. Lat. 786 m.
 Quest VI. Course N. 53° 08' E. Lat. 30m. Dep. 48cm.
 Quest. VII. Dist. 1181m. Lat. 452m. Dep. 1091m.
 Q. VIII. Course S.W.b.S. $\frac{1}{2}$ W. nearest Lat. 122, 14m. Dep. 93, 14m
 Quest. IX. Dist. 250m. Lat. 20cm. Dep. 150m.
 Quest X. Dist. 840, 093 m. Lat. 640, 093m. Dep. 544, 093 m.
 Quest. XI. Course N.E.b.N. $\frac{1}{4}$ E. Dist. 133, 133 l. Lat. in 5° 20' N.
 Q. XII. Courses W.b.S. 1° 21' Westerly, Dist. 516 $\frac{1}{2}$ m. Dep. 295 $\frac{1}{2}$ m.
 Quest. XIII. Course S. E. $\frac{1}{4}$ E. nearest Dep. 444m. Lat. 333m.
 Quest. XIV. Course S.W.b.S. 1° 29' 44" Westerly, Dist. 801, 9 l.
 Diff. Lat. 656, 9 l. Dep. 459, 9 l. Lat. in 19° 56' S.
 Quest. XV. Course N. 50° 22' E. Dist. 60 l. Dep. 45, 87 l.
 Quest. XVI. Dist 96 $\frac{1}{2}$ l. Dep. 34 $\frac{1}{2}$ l. to and from the Equator.
 Quest. XVII. The Second Ship's Dist. 665 l. Lat. and Dep. of each 470 l.
 Quest. XVIII. Each Ship's Dist. is 665 l. and Dep. 470 l.
 Quest. XIX. 172 Fathom of the Best Bower-Cable.
 Quest. XX. Northermost Ship's Course is S. 74° 19' E. Dep. 712 $\frac{1}{2}$ l. The middlemost Ship's Course is S. 57° 15' E. Dep. 588 l. The Southermost Ship's Course is S. 30° 20' E. Dep. 353 l.
 Quest. XXI. The *Revenge* sailed 47 l. the *Torbay* 71 l. the *Orford's* Dist. sailed is 153 l. her Lat. 128 l. and the *Cornwall's* Dist. was 101 l. her Dep. 56 l.
 Quest. XXII. First Ship's Course is N. 44° 14' E. Second Ship's Course is S. 23° 16' E. the rest is obvious.

Quest.

Quest. XXIII. Ship's Easting from A to B is 27 m. Lat. of the Port B, $45^{\circ} 36' N$. Course from A to B. $N. 36^{\circ} 52' E$. Dist. from B to C, is 60m. and Second Course steer'd is $S. 57^{\circ} 07' E$.

Quest. XXIV. $\left\{ \begin{smallmatrix} 37\frac{1}{2} \\ 30 \end{smallmatrix} \right\}$ Miles Dist. the Ports $\left\{ \begin{smallmatrix} A \& B \\ A \& C \end{smallmatrix} \right\}$ are a furth^r der.

$\left\{ \begin{smallmatrix} 1 \\ 2 \end{smallmatrix} \right\}$ Dep. $\left\{ \begin{smallmatrix} 13,5 m. \\ 24 m. \end{smallmatrix} \right\}$ Course from $\left\{ \begin{smallmatrix} B \text{ to } C, N. 36^{\circ} 18' W. \\ C \text{ to } A, S. 53. 07. E. \end{smallmatrix} \right\}$

Q. XXV. $\left\{ \begin{smallmatrix} \text{Dist.} \\ \text{Dep.} \\ \text{Course} \end{smallmatrix} \right\}$ from $\left\{ \begin{smallmatrix} 30 m. \\ 44 m. \end{smallmatrix} \right\}$ A to D $\left\{ \begin{smallmatrix} 22, 2 m. \\ 13, 5 m. \\ S. 36^{\circ} 18' E. \end{smallmatrix} \right\}$ D to B.

Q. XXVI. $\left\{ \begin{smallmatrix} \text{Course} \\ \text{Dist.} \\ \text{Dep.} \end{smallmatrix} \right\}$ from $\left\{ \begin{smallmatrix} NE. \frac{1}{2} E. \\ 30, 2 l. \\ 43, 8 l. \end{smallmatrix} \right\}$ A to C $\left\{ \begin{smallmatrix} S. 41^{\circ} 38' E. \\ 21, 7 \\ 14 \end{smallmatrix} \right\}$ C to B. } Lgs.

Q. 27. the Isles $\left\{ \begin{smallmatrix} A \& C \\ A \& B \\ C \& B \end{smallmatrix} \right\}$ are distant. $\left\{ \begin{smallmatrix} 38, 3 l. \\ 31, 35 l. \\ 19, 72 l. \end{smallmatrix} \right\}$ bears $\left\{ \begin{smallmatrix} N. 54^{\circ} 42' E. \\ S. 34^{\circ} 41' W. \\ E. \& W. N. \& S. \end{smallmatrix} \right\}$

Quest. XXIII. Dist. 50m. $\propto$ Lat. 30m. Dep. 40m. Course $S. 53^{\circ} 07' W$.

Quest. XXIX. Be the 31st Prop. 3^d Book of *Euclid*. 'tis prov'd, that an Angle in a Semicircle is a Right Angle; *Ergo*, To what Place soever the Ship was blown from A, right before the Wind, and put a-shore, the same Wind upon the Beam, would carry her to the Port opposite, at B.

Quest. XXX. Course to the Port B, is $N. 70^{\circ} 32' E$. or near $E. N. E. \frac{1}{2} E$. demonstrable by *Euclid*. Lib. 3. Prop. 20.

Quest. XXXI. Admits of a like Construction and Solution as Question 22^d foregoing.

In Oblique Plain-Sailing.

Quest. I. Course $S. 26^{\circ} W$. Distance 116 Leagues.

Quest. II. $N. 61^{\circ} E$, the Course requir'd.

Quest. III. $S. 37^{\circ} 58' W$. Distance 6,42 m.

Quest. IV. $S. 58^{\circ} 46' W$. and $N. 58^{\circ} 46' E$. Distance 9,7m.

Quest. V. First Ship's Dist. 10,45m. Second's Dist. 4,65 m. their Bearing is $N. 37^{\circ} 14' E$. and $S. 37^{\circ} 14' W$.

Quest. VI. The Head-Lands bear $N. 88^{\circ} 53' E$. and $S. 88^{\circ} 53' W$. nearest Dist. 7,95 m. the Eastermost Head-Land from the Island $S. 14^{\circ} 30' W$. Dist. 9,15 m. and the Westermost Head-Land from the Island $N. 32^{\circ} 15' W$. Dist. 10,6m.

Quest.

Quest. VII. The Cruiser must sail $S. 26^{\circ}. 43'. E.$ 173,6m. and in 24 H. 48 M. time, he will fall in with the Fleet.

Quest. VIII. the Buoy bears from the First Head-Land $E. N. E. \frac{1}{2} E.$ Dist. 45m. and from the Second Head-Land nearest $W. S. W. \frac{1}{2} W.$ Dist. 74m. the Second Isle bears from the Second Head-Land, $S. \frac{1}{2} E.$ nearest 115m. the Rock bears from the Second Island $W. S. W.$ Dist. 54m. the First Isle bears from the Rock $W. b. N. \frac{1}{4} W.$ Dist. 99m. and the first Head-Land bears from the First Island $N. b. E. \frac{1}{2} E.$ 100m. nearest.

Quest. IX. Courie $N. E.$ Distance from the Grand Ganary, 105m. Lat. she took the Parate in, was $26^{\circ}. 45'. N.$

Quest. X. She must run 13,0635 l. before she Tacks, and then afterward 7,69037 upon the Second Tack.

Quest. XI. The First Ship sail'd 45 l. and the Second $80\frac{1}{2}$ l.

Quest. XII. Second Ship's Course is $W. S. W.$ First Ship's Dist. $49\frac{1}{2}$ l.

Quest. XIII. The Westermost Ship's Dist. is 85 l. the Eastermost Ship's Dist. 51 l. and her Course is $N. N. W. 0^{\circ}. 12'. N.$

Quest. IV. Dist. on the First Course 133m. on the Second 96m. her Distance from the First Island 113m.

Quest. XV. The $\left\{ \begin{array}{l} \text{Northermost} \\ \text{Westermost} \\ \text{Eastermost} \end{array} \right\}$ Ship's Course $\left\{ \begin{array}{l} \text{South.} \\ N. E. b. N. \frac{1}{4} E. \\ N. 67^{\circ}. W. \end{array} \right\}$
their Dist. to the Island 45m.

Quest. XVI. The Westermost Ship's Dist. is 105, 1575 l. the Eastermost 140, 195 l. and bear off each other, $E. \frac{1}{2} N.$ and $W. \frac{1}{2} S.$ and they were 2 Days, 22 Hours in sailing to their several Ports.

Quest. XVII. $\left\{ \begin{array}{l} 45,8103 \\ 54,0256 \\ 59,1641 \end{array} \right\}$ L. upon the $\left\{ \begin{array}{l} N. E. b. E. \frac{1}{4} E. \\ N. W. \frac{1}{4} W. \\ \text{South.} \end{array} \right\}$ Course

Quest. XVIII. The First Ship's Course is $N. 41^{\circ}. 19'. W.$ Dist. 299m. and the Second Ship's Course is $N. 60^{\circ}. 51' E.$ 461 Miles.

Quest. XIX. The First Ship's Dist. is 139m. and the Second's Dist. 147m.

Quest. XX. She sail'd 119m. $N.$ and 25m. $S. E.$

Quest. XXI. Dist. from the Ship to A, is 75 L. to B, 145 L. to C, 117m.

Quest. XXII. If the Learner please to Project, he will form the Figure of a *Rhumb Chart*: The Distances or Bearings of each Island from the Ship (or Center) he may find by the First and Third Case of *Oblique Sailing* in the foregoing

Trac-

any two immediate Conjunctions, is equal to $29\frac{1}{2}$ Days; and *January* containing 31 Days therefore, if to the Age of the Moon on the First of *January*, be added $1\frac{1}{2}$, or (to avoid Fractions) 2 Days, the Sum will be the Age of the Moon on the First of *February*. And because in common Years the Days in *January* and *February* taken together, make 59, which is exactly equal to two intire Lunations; therefore the Age of the Moon on the First of *January* will be the same with its Age on the First of *March*; and consequently to its Age on the First of *January*. There is nothing added in common Years: For then it's on the First of *March*; but in Leap-Years, the Sum of the Days in *January* and *February* being 60, which is more than two entire Lunations by 1 Day, it is evident that in this Case, we must add 1 Day to the Moon's Age on the First of *January*, and the Sum will be its Age on the First of *March*.

And by the same way of Reasoning, it will appear, that to find the Age of the Moon on the First Day of any Month, we must add to its Age, on the First of *January* the following Numbers, viz. for *February*, 2; for *March*, 0, in Common Years, and 1 in Leap-Years; for *April*, 2; for *May*, 3, &c. As, in Common, these Additional Numbers are called, *the Numbers of the Months*.

A NOTE for the better Direction and Preservation of Ships that use the British Channel and West-Indies.

WHereas it has been many Years found by sad Experience, that not a few Ships, sailing for the British Channel, have missed of their true Course, and unexpectedly fallen into the (Bristol, or) St. George's Channel, among some of the Rocks of *Scilly*, not without great Delays and Dangers, and the Loss of many of them (of which Sir *Cloudfly Shovell* and his Fleet was a dismal Instance :) And whereas the present Light-House on *St. Agnes's Island* there, tho' otherwise very useful, is yet so far from being always an effectual Remedy in this case, that Dr. *Halley*, and others, who nicely view'd that Place, have observ'd, that in Foggy Weather 'tis not safe to trust a Ship in the Night near its Latitude, in expectation of seeing that Light; because 'tis more than probable, such Expectation, may have occasion'd the Loss of many Ships:

It has been observed by an Experienc'd Commander, who used the *West-India* Voyages for many Years from *England*, that in about the Latitude of $48^{\circ} 30'$, open with our *British* Channel, having a good Observation, at the same time it proving Calm and Smooth Water, insomuch that he handed his Sails, and so lay for 48 Hours—. The first 24 Hours at Noon, he Observed again, with clear Weather, and found by the same that he had drove to the Northward 26 Miles, which made him mistrust his former Observation, tho' his Mate agreed with him; because the Ship had not gone, to his Knowledge, one Mile; and upon Review, he found he was not mistaken. The next 24 Hours, being still calm, he had again another good Observation, and then found himself about 26 Miles to the Northward of his last Observation, which confirmed him he was right the Day before; and that this must be imputed to a strong Northern Indraught or Current there. He gave notice of it to others, and was always aware of it himself: For when you come near the Soundings, and till you bring *Ussant* South of you on the E. S. E. Course, you will hardly hold your Latitude; and the general Course is E. N. E. or E. b. N. if but a small matter to the Southward of 49° Latitude: And he says, that would have been my Course, if he had not met this Opportunity of discovering this strong Indraught; and for want of Observation, must have run up *St. George's*, or the North Channel, as many have, and still do, for want of the same.

After his last Observation, the Wind sprang up; and making Allowance for the said In-draught, the next Day he was brought into Soundings, and the following Day he was brought in sight of the *Lizard*, by steering to the Southward of the East. Wherefore the best, ablest and ancientest Commanders may as well be deceived in this Case, as the young and less-knowing, by the means of the said Northern Indraught, and run up one Channel for another.

Thus, many Ships have made *Wales* for *England*, and *Lundy* for *Ussant*; and thereby for a while have been so surpriz'd, and at a loss, that they knew not what Course to steer.

The Danger in this Case is most eminent, when in the Night, or in hazy thick Weather. And I need not any farther Testimony to confirm this, than from those who have found it too true, to their great Peril, Loss and Grief.

'Tis advisable also to observe the Colour of the Sea; thereby to know whether you are in Soundings, or on any Banks: For the foresaid Commander, in many Voyages to *Barbadoes* discover'd a Bank to the Windward of *Barbadoes* about 60 Leagues.

Leagues: He being so well acquainted with the Change of the Water, made the Bank very plain; as did others in the said Ship; and he also perceiv'd when the Ship went off it, it being very discernible; and 30 Leagues Sail after brought his Ship to the Island. After which, in running down to Jamaica, in the Latitude of Antegoa, although so far to the Northward of Barbadoes, yet he saw the Bank in that Latitude, which runs to the Southward of Barbadoes; but not so plain as it appears further Southerly.

There is about 100 Fathom of Water on this Bank, about 60 Leagues off the Island, and fine white Sand at the bottom, which is the reason it shews so plain: It is much plainer to be seen, than in 60 Fathom in our Channel.

And for farther Confirmation, the said Captain, in a Voyage to Barbadoes from the Bay of Campeache, made the same Bank; and said before his Officers, and several of his Men, that the next Day by that time, if the Wind held, they should see Barbadoes. The Gunner being by, made this Answer, that he had been at Barbadoes several Voyages with several Commanders (which he named;) and we always, said he, laid by several Nights, and run down in the Days, for fear of missing the Island: But I never heard any body say before, when he should see it; adding further, if it please God, I will be at the Top-Mast-Head at that time. Accordingly the next Day he did go to the Top-Mast-Head about 3 a-clock in the Afternoon; 4 a-clock being the time mention'd, the Bell ringing for 4, the Gunner call'd down, and said, he saw no Land. The Captain made him no Answer, his Eye being on a white Cloud, that he was sure, hid the Land, it being before it: In two or three Minutes after the Gunner had call'd, the Captain saw the Top of the Hill break thro' the Cloud; which made him call to the Gunner to know if he saw the Land; he answer'd, No. The Captain bid him come down, and he would shew it him. Upon which, the Gunner look'd again, and cry'd out, Land! Land! And at his coming down, he declar'd, he never heard, nor saw the like before.

This same Commander sailing from Barbadoes for Jamaica, running down between St. Vincent and Malaxea, said, he met with a very unusual Current running to Windward: We sail'd (said he) from Barbadoes in the Evening; and the next Morning we were near those Islands with a fresh Gale right before the Wind, and ran about 5 Knots, and so ran all that Day between the Islands, and were not clear of them by 6 a-clock in the Afternoon: Which shews the Current very strong at that time.

This brings me to mention another Observation I made in my Run from the West End of Hispaniola to Jamaica. If I took my Departure upon a Full or Change of the Moon, I found I made many Leagues more than I did at the Quarter of the Moon. At the Full and Change I was looking out for the Land, long before I saw it: And at the Quarters I was down upon it long before I look'd for it. The Reasons, as I found afterwards, were, that the Full and Change made a strong Windward Current; and the contrary on the Quarters. Those who have not been acquainted with it, have met with Disappointments; and some, after they have run the Distance between both Islands, and not seen the Land, have thought themselves either to the Northward or the Southward of it; and so have run sometimes to the Northward, and seeing no Land, have run to the Southward again; and so spent some Days before they found the Island; which hath very much surprized several Commanders.

Others running down upon the Quarter of the Moon, have run the Ground before they look'd for the Land, and so run to the Northward of the Island, and have been several Days getting up again. I have known me to be a Week, till the Current hath changed.

This is by way of Advice to the New and Young Traders that Way. I cannot think I have said more than all Ancient Commanders know before this time.

Another time, standing to the Southward from Barbadoes from 8 till 12 at Night upon a Wind; and then having tackt and stood in again, expecting to fetch the Road from which I went, by Day-light, I could not fetch any Part of the Island for two Days after. This shews, that I then met with a strong Leeward Current; as I had before a Windward one. I pray God none may incur too great a Hazard out of a supercilious Disregard to what is herein most kindly recommended to them.

*Vive, vale: si quid novisti rectius istis, Candidus, imperti;
Si non, his utere mecum.*

The END of the First Part.



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